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ABSTRACT

These preliminary breeding bird studies in 1993 were part of the Donna Creek Biodiversity Project in the ESSF 240 km north of Prince George B.C. A 2x2 ANOVA design determined stub effects (3-m tall stumps at 8-10/ha) and tree island effects (1/4-ha tree patches occupying about 3 % of the area) within clearcuts on breeding bird detection densities. Three clearcuts, each of approximately 100 ha, were divided into 4 treatment units of each combination of presence/absence of the stubs and tree islands. Breeding birds were sampled by transects from May 14 to July 13, 1993. Concurrent sampling within adjacent old-growth forest allowed comparisons to unharvested forest controls. Species with greater than 9 detections in 1993 were included for analysis.

The presence of stubs in clearcuts had significant positive effects on woodpeckers, Tree Swallows and Olive-sided Flycatchers. Retention of tree islands within clearcuts had significant positive effects on woodpeckers as well as Olive-sided Flycatchers, Swainson's Thrushes, Yellow-rumped Warblers, Blackpoll Warblers, Wilson's Warblers and Red-breasted Nuthatches. Significant positive interaction effects for woodpeckers, Olive-sided Flycatchers and Yellow-rumped Warblers indicated that the combined positive effect of stubs and tree islands was greater than the simple additive effect of the two factors for these birds.

Tree islands had a significant positive effect on total bird densities and species richness. Woodpeckers and 15 other species of birds were detected more often in tree islands than would have been expected based on the area of the clearcut occupied by the tree islands. The effect of these tree islands was clearly disproportionate to their small area: they occupied about 3 % of the area but contributed 47 % of the singing bird detections in treatments where they were present. Even with tree islands, singing bird densities in the clearcuts were still only 26% of the densities in the adjacent Old-Growth forests. The 1/4-ha tree islands may be too small for breeding use by at least 8 forest bird species that may require larger tree islands.

The presence of stubs resulted in higher species richness but the stub effect was smaller in magnitude than the tree island effect and was not significant using only 3 replicates. Cavity-nesting birds were detected proportionately more often on stubs than non-cavity nesting birds. Woodpeckers were detected on stubs more often than expected compared to other cavity-nesters. Tree Swallows nested in at least one stub and had the strongest association of any species to stub treatment areas, even though they were detected less often on stubs than other cavity-nesters. Measures of stub importance therefore need to consider more than detection frequencies of birds on stubs.

Recommendations are made to continue this study on breeding birds with refinements to the sampling techniques, particularly for sampling cavity-nesting birds.

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1.0 INTRODUCTION

The Donna Creek Biodiversity Project was initiated in 1990 as a cooperative venture of the Peace/Williston Fish and Wildlife Compensation Program (a joint initiative of B.C. Hydro and B.C. Environment) and Fletcher Challenge Canada Ltd. The aim of the project is to develop and test alternative timber-harvesting techniques designed to benefit tree-cavity-nesting birds and mammals. Animals that nest or roost in tree cavities are at some risk in the managed forest because Worker's Compensation Board regulations prohibit the maintenance of any standing diseased or dead trees taller than 3 m on worksites (Backhouse 1993). This project was designed to test whether maintenance of 3-m tall high stumps (stubs) and small residual tree islands benefit cavity-using animals within clearcuts. Reports detailing the initiation and first phases of this project have been previously released (Dawson et al. 1992, Murray 1992a, Murray 1992b, Wood 1992, Wood 1994). Some of the bird observations made during this study with respect to species ranges have been published elsewhere (Price 1993).

1.1 Objectives

The primary objective of this portion of the Donna Creek Biodiversity Project was to determine breeding bird responses to two alternative forest harvesting techniques—the retention of residual tree islands and creation of 3-m stubs within clearcuts. By comparing breeding bird densities (numbers of detections per unit area) between these experimental timber-harvest treatments, and between the treatments and Old-Growth control forests, the responses could be measured. Cavity-nesting birds were the focus group for this study since the alternative harvesting techniques have been proposed to mitigate the effects of clearcutting on them in particular, but data was also collected for other breeding passerines.

Because this was the initial year of this breeding bird study, a second objective was to assess the sample design and sampling efficiency by reviewing methods, protocol, timing and analysis techniques. This will enable further studies to concentrate on methods and times best suited for the target species or groups identified within this report. More detail was included in this assessment than might be usual for an interim project report because this document is a reference point for future breeding bird studies within the Donna Creek Biodiversity Project.

2.0 STUDY AREA

The Donna Creek study area is located at the south end of the Wolverine Range of the Omineca Mountains, approximately 80 kilometres northwest of Mackenzie and 240 km north of Prince George, British Columbia (Figure 1). Detailed location notes and geographical descriptions of the study area are available in Dawson et al. (1992). The study area is in the Manson Plateau Ecosection of the Omineca Mountains Ecoregion of the Sub-Boreal Interior Ecoprovince. The study plots are in the moist very cold variant of the Engelmann Spruce Subalpine Fir Biogeoclimatic Zone (ESSFmv3). This zone is characterized by an ericaceous shrub layer, a sparse cover of herbs, and a relatively dense moss layer. Engelmann spruce and subalpine fir are the dominant climax tree species, with lodgepole pine as a widespread seral species (Dawson et al. 1992).

The characteristics of the experimental cutblocks have been described by Wood (1992). To briefly summarize, three cutblocks were chosen for this study (Cutting Permit 371, Block 516, and Cutting Permit 373, Blocks 5546 and 5547), located between 1000 and 1330 m, with the lower portions located in the valley bottom of the main tributary to Donna Creek. Most of the area of the cutblocks is on moderate to strong undulating slopes (13% - 24%) with a southwest exposure. The uneven topography results in a complex of soil moisture regimes including well drained slopes, wet seepages and ponded areas on plateaus. Each of the blocks is described below in numerical order.

Experimental Block 5516 (119.8 ha)

This Block has been referred to as either 516 (Dawson et al. 1992, Wood 1992) or 5516 (on the provided block maps). "5516" is used throughout this report to refer to this block. Block 5516 is 2.5 km southeast of Block 5546. The transects in this cutblock sampled areas between 1080 m and 1330 m. The entire area was on a complex of steeper slopes and plateaus well above the valley bottom. The 20.8% (average) slopes faced west (in the north part of the block) and southwest. The area, which was crossed by many runoff creeks, was the wettest of the three cutblocks surveyed. This block had the greatest elevation change from top to bottom. Seven patches of forest (hereafter referred to as tree islands), each of about 1/4 ha, were created. One additional tree island was about 1 ha in size. Block 5516 was logged in August/September 1992 (Wood 1992). During the 1993 breeding bird surveys, the ground was covered with considerably more slash than occurred in the other two blocks, and much of it was still green.

Experimental Block 5546 (90.6 ha)

Transects in this cutblock sampled areas between 1000 and 1130 m. A small portion (Transect "N") was located in the floodplain of a tributary to the main tributary of Donna Creek and was dissected by several runoff channels and ponds during the freshet. Most of the area was on southwest facing slopes (24% slope). This was the smallest cutblock and

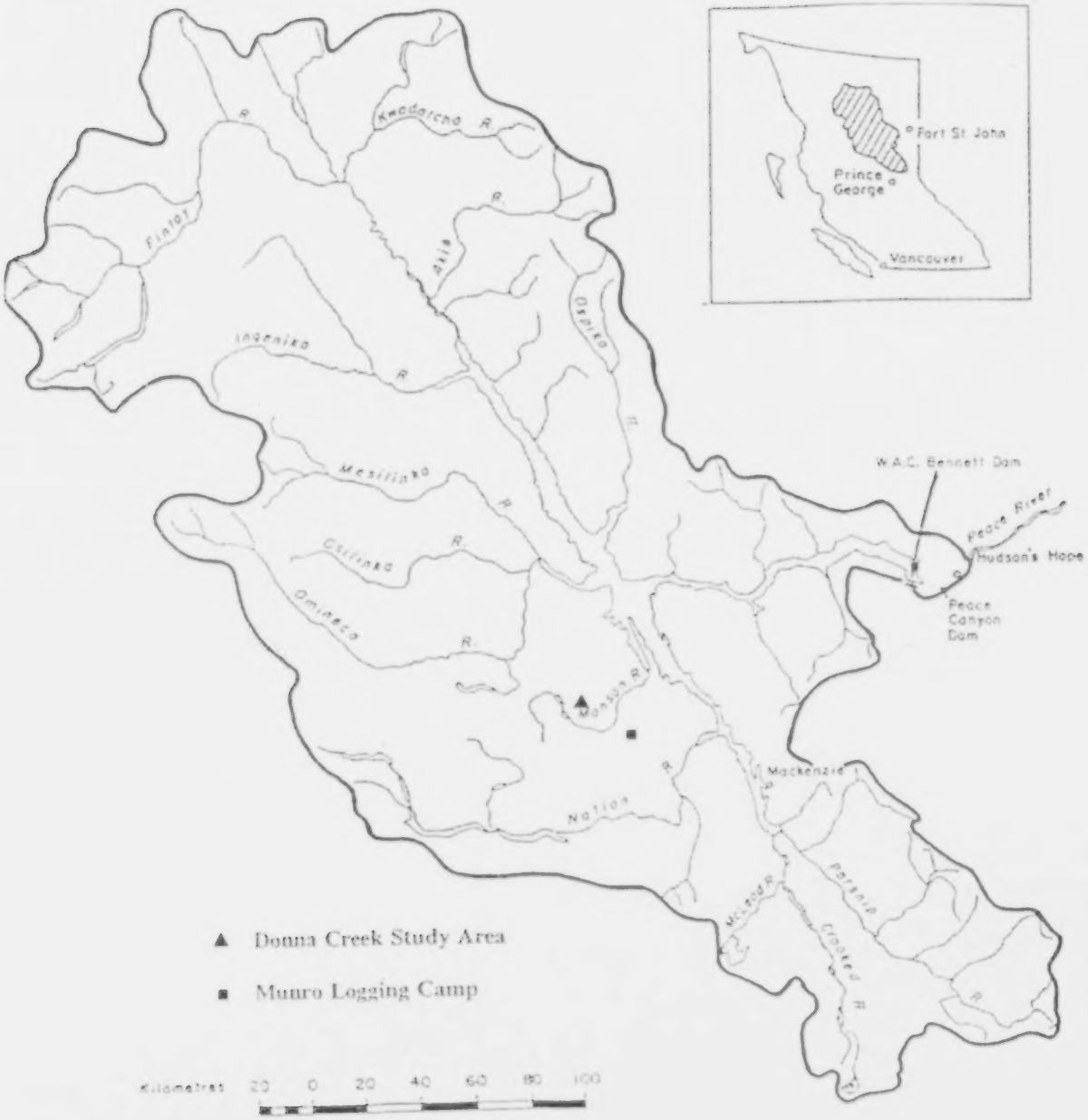

Figure 1 Location of the Donna Creek Study Area in British Columbia.

had the least elevational change from top to bottom. Six tree islands, each 1/5 to 1/4 ha in size, were left. Block 5546 was logged in October 1991 (Wood 1992). It was planted with Engelmann spruce and lodgepole pine in late May, 1993. Block 5546 is southwest of Block 5547 separated only by a 400-m band of old-growth forest. This band served as one of the control Old-Growth areas.

Experimental Block 5547 (111.5 ha)

Transects in Block 5547 sampled areas between 1010 and 1170 m. The main tributary to Donna Creek flowed through this cutblock with the lower quarter of the block located in the valley bottom of this tributary. The terrain in the lower area was relatively level and dry. Eight tree islands, each 1/5 to 1/4 ha in size, were left. Block 5547 was logged in October 1991 (Wood 1992). It was planted with Engelmann spruce and lodgepole pine in late May, 1993.

3.0 METHODS

3.1 Study Design

The study design was a randomized block two-factor ANOVA with 2 levels of each factor (i.e., a 2x2 ANOVA). The design permitted determination of the main effects of each factor on breeding bird densities and richness, as well as the interaction effects of the factors (Table 1). The first factor was the retention of stubs (high stumps cut at 3-m height by the feller buncher) within the clearcut. Levels chosen were 1)absence and 2)densities of 8-10/ha. The second factor was the retention of green tree islands within the clearcut. Levels chosen were 1)absence and 2)3-4 tree islands, approximately 1/4 ha each in size, per treatment unit. There are four possible combinations of these two factors at these two levels:

Clearcut (CC): no stubs-no tree islands,
Stub (SB): stubs but no tree islands,
Tree-Island (TI): tree islands but no stubs,
Stub-and-Island (SI): stubs and tree islands.

Table 1. 2x2 ANOVA table used for analysis of breeding bird detection densities within experimental blocks.

Source of Variation	Degrees of Freedom
Stub Effect (S)	1
Tree Island Effect (I)	1
Interaction Effect (S*I)	1
Block Effect (B)	2
Error	6
	11 total d.f.

Each of these four treatments were applied to about one-quarter of each of the 3 experimental blocks providing for a randomized block study design with 3 replicates of each treatment. Each of the treatments is referred to hereafter by the two-letter code (CC, SB, TI, or SI) to avoid confusion between the stub and tree-island factors, and the treatments (which are a each a combination of two factors).

Table 2. Total areas and sampled areas of experimental Treatment Units and Old-Growth Controls.

Treatment Unit	Block 5516		Block 5546		Block 5547	
	Area	Sampled Area	Area	Sampled Area	Area	Sampled Area
Clearcut (CC)	34.8	21.87	23.7	18.25	24.7	17.78
Stub (SB)	31.8	23.48	20.0	16.05	32.6	34.93
Tree-Islands (TI)	27.7	27.25	26.5	19.50	30.7	26.10
Stubs-and-Islands (SD	25.5	20.25	20.4	15.32	23.5	16.23
TOTALS	119.8	92.85	90.6	69.12	111.5	95.04
Adjacent Old-Growth Controls		22.50		20.63		22.88

Since old-growth forest surrounded each of the cutblocks, an approximately equivalent sampling area to each of the treatment units (about 25 ha) was designated in old-growth forest adjacent to each of the cutblocks. This permitted comparisons of mean breeding bird use in each of the four treatments with the mean use in the old-growth forest. The choice of old-growth controls did not allow for the randomized block design since the old-growth control for Block 5546 was in the corridor of forest between blocks 5546 and 5547. There was no good basis to assign this as a control for one block in preference to the other block. A completely randomized design was therefore used for old-growth to treatment comparisons.

3.2 Sampling Design and Methodologies

The survey technique chosen for breeding birds was a transect method using a maximum 75-m sampling distance from the centerline of the transect using an approximation to the methods of Emlen (1971) (Dawson et al. 1992). Transects in each experimental block were oriented across the predominant mountain slope and extended from one edge of the experimental block to the other. Each treatment unit of each experimental block was sampled by 2-6 transects depending on the actual shape and orientation of the treatment units with respect to the transects (see Appendix 3). Treatment units were not of equal area (Table 2) or shape. Some treatment units were sampled predominantly by one transect because the transect happened to be along the long axis of the treatment unit. Other treatment units were sampled by as many as 6 transects because the transects ran at right angles to the long axis of the unit. Areas sampled by individual transects within treatment units varied from 1.05 to 11.80 ha.

Twelve breeding bird survey rounds were completed on each transect in the two-month period from May 14 to July 13, 1993 at approximately 5-day intervals. The duration

of the survey period was longer than originally planned due to tree planting on the experimental cutblocks that interrupted bird sampling and due to exceptionally rainy weather. Original plans were to complete 12 survey rounds by late June or early July. Every transect was sampled in one survey round before repeat sampling of transects began in the next survey round. The only exceptions to this were: on the first survey round on Blocks 5546 and 5516, old growth transects were only half completed; on the fourth survey round on Block 5547, Transects D and 1d were not sampled; and on the fourth survey round on Block 5516, neither of the Old Growth transects were done due to the presence of a grizzly bear.

Breeding bird transects were sampled beginning at, or shortly after, sunrise. The sampling on a single experimental block and adjacent Old Growth was completed by two observers, working on different transects, in a single sampling day. Between each survey round, observers alternated transects and directions (sometimes starting from the end of the transect) to minimize observer bias. Surveys were not initiated in fog or rain, or if heavy rain appeared to be imminent. Although the objective was to be finished sampling by 10 A.M. on each sampling day, this objective was not consistently achieved until late June. The terrain made walking slow and transect locations were indistinct for the first three survey rounds. During the first three survey rounds, when sampling routinely continued past noon (as late as 2:15 P.M.), the Old Growth transects were always the last to be completed to minimize any bias that time-of-day may have had on the comparisons made between treatments within the cutblocks.

3.3 Data Collected

General transect information which was recorded for each transect on each survey included start and finish times, weather, block number, transect ID, treatment and observer. The data recorded for each bird or each family group or flock of birds detected on the transects included bird species, number, age and sex if known, subspecies if known, activity, habitat feature used, and location.

The transects were flagged at 10 meter intervals along the centerline. At 100-m intervals along the centerline, flagging was placed laterally at 25, 50 and 75-m distances from the centerline to aid observers in distance estimation. The bird's location was noted to the nearest 10 m interval along centerline, as well as the distance laterally to the nearest 10-m interval, up to a distance of 50 m from centerline. Birds between 50 and 75 meters were grouped into a 25-m interval. Birds moving back and forth across the transect route were recorded at "O" m rather than at the point of first detection. The actual locations were also used to assign bird detections to one treatment unit or another since transects crossed the experimental blocks and most transects sampled more than one treatment unit. For the first few surveys, the boundaries of treatment units were not clearly marked so that birds had to be later assigned to a treatment unit from the database based on their recorded location.

Usually, the first detected activity, habitat feature used and location were recorded for each bird or flock. However, if birds exhibited more than one activity and/or were moving about, and more than one habitat feature was used, the most "significant" feature and activity was recorded. This took into consideration such factors as the length of time spent in/on that feature, the type of feature (non-ground was given higher priority than ground), the activity exhibited on each feature (singing was given priority), and (the most common case), the bird location before being disturbed and/or when first noticed. These priorities were assigned to better address the use of the two experimental factors, particularly in response to territorial behaviours.

The non-ground features which were given higher priority included the two factors under study here (stubs and tree islands) as well as residual young conifers scattered throughout the blocks. "Snags" was intended to refer only to the 3-m stubs deliberately left in harvested areas of the cutblocks. Occasionally, snag-like slash features being used by birds were also called snags. This feature included snags at the perimeter of islands, but not any which may have occurred within the islands. Use of stubs was not recorded separately from "snags". This accounts for the "snag" use regularly recorded within the treatments that had no 3-m stubs. Ground included, in addition to bare ground, any low feature such as grass/forb, low shrubs, and stumps, logs and other scattered slash. Young conifers were scattered young trees which had been left behind during the logging operation. Young conifers appeared to provide a focus for the territories of non-cavity-nesting passerines. These were given priority only when use of these features was independent of known observer influence, or when a priority activity was observed there. The use of features other than snags and tree islands were not analyzed here. Should other features be quantified in the future, then re-analysis of this data may be appropriate.

Priority activities included those which showed evidence of territoriality or nesting. Of these, singing had the highest priority. The following examples illustrate how the priorities were applied:

1. A Black-backed Woodpecker is observed foraging on a snag, then flies into an adjacent island and begins drumming. It would be recorded as "singing" in "mature" forest. Had it not begun drumming after flying to the island, it would have been recorded as "foraging" on a "snag".

2. A Dark-eyed Junco is observed foraging on the ground, from which it flies to perch for 15 or 20 seconds on a snag before flying out of sight. It would be recorded as "perching" on a "snag". Had it alighted only briefly on the snag, it would have been recorded as "foraging" on the "ground".

3. A Chipping Sparrow is observed perching in a young conifer. After the observer has moved 50 m past the bird along the transect, the bird gives a brief song then resumes

perching. It would be recorded as "singing" in a "young tree". Had it not sung, it would have been recorded as "perching" in a "young tree".

Incidental to the regular sampling observations, all nesting activity of cavity-nesters was recorded whenever it was noticed. Data recorded included species, number and age of birds, location relative to transects, the snag, stub or tree used, and the bird behaviour.

3.4 Data Analysis

The study design and appropriate data analysis procedures were not completely identified before field sampling. Consequently, some of the data analysis is actually exploratory in nature and consists of examination of some of the assumptions of the methodologies as well as consideration of alternative methods of analysis to those first identified by Dawson et al. (1992). This section describes the analyses used as well as reporting on some of these preliminary analyses that assisted in identifying these methods of analysis.

All analyses were done using NCSS software (Hintze 1992) and all Power analyses using the NCSS-PASS module (Hintze 1993) except for Dunnett's Procedure which was done on a pocket calculator using means and variances provided by the NCSS software. All tests made were two-tailed since individual species could respond positively or negatively to any of the factors or treatments. The probability of a Type I error *(a)* was set at 0.05 throughout the analyses to test for significance except for tests of interaction effects where 0.10 has been used (see Between Treatment Comparisons below). Species are presented in tables in American Ornithologists' Union (1983) order and their standardized common names have been used.

3.4.1 Bird Densities

All birds detected within 75-m of the transect lines were recorded but transects were sometimes less than 75 m from the edge of the cutblocks so that they often included birds in forest edges that were not in any treatment unit. These birds were excluded from all analyses because they were not in the treatment units. The area sampled in the forest edges were also excluded from transect totals. Birds recorded as over-flying transects were also not included in the analyses.

Distance from transect center line was recorded for every bird detection up to the 75-m limit from center line so that narrower detection distance limits (where detection probability is 100% for active or singing birds) could be used for certain species for density estimates. The actual data must be graphed and examined closely to determine what these distances are for each species. Typical "break-points" of the decline in detection ability of

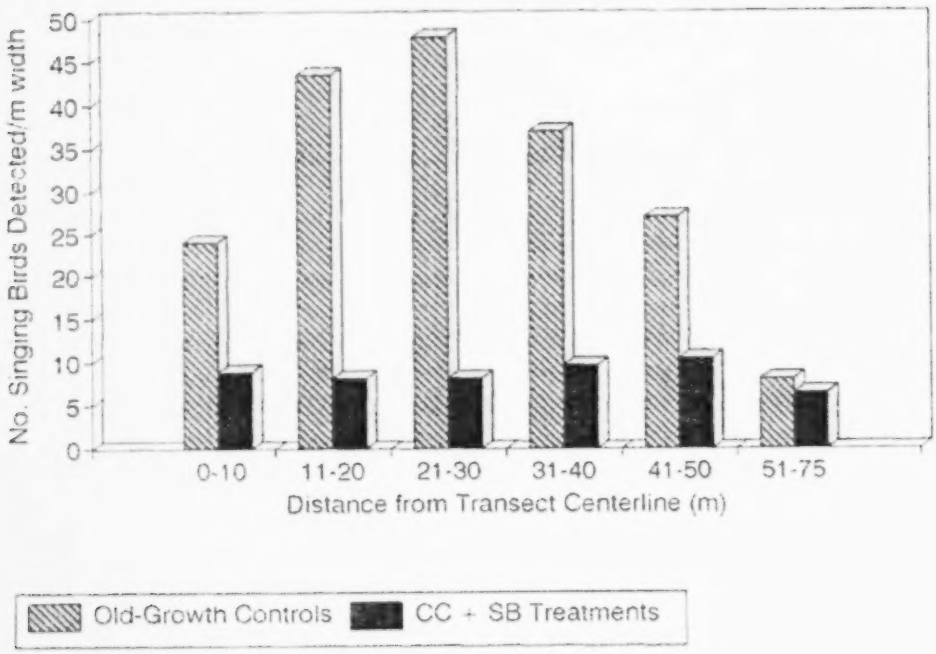

Figure 2. Numbers of singing birds counted by distance from transect centerline in Old-Growth Controls and Clearcut (CC) and Stub (SB) Treatments.

singing passerines are at distances of less than 50 m in closed forest habitats, e.g. Roeder et al. (1987). This difference in detectability may be especially pronounced when comparing habitats that differ greatly in degree of openness such as clearcuts and forests.

In the CC and SB Treatments, singing detections of all bird species declined only very slightly beyond 50 m (9.06 birds per m-width from 0-50 m vs. 8.2 birds per m-width from 0-75 m; Figure 2). The TI and SI Treatments could not be used for this estimation because the bird detections were clumped within the tree islands in these areas and the tree islands were not uniform in distribution from centerline. On the Old-Growth transects, using a 75-m width instead of a 50-m width may have contributed to a 26% underestimate of bird densities (35.88 birds per m-width from 0-50 m vs. 26.60 birds per m-width from 0-75 m; Figure 2). The total singing bird densities actually found in the CC and SB Treatments were 65 to 90% below the densities in the Old-Growth Controls. In this case, even a potential underestimate of 26% in Old-Growth densities caused by using a transect width that was too

wide for 100% detection probability, would not change the significant differences in densities between Old-Growth Controls and treatments (see Results) because the observed differences were much greater than 26%. Despite this potential source of error, the 75-m width from centerline was used in analyses, primarily because the transects did not sample uniform habitat (forest edges, tree islands, and boundaries of treatment units that ran diagonally across transects) so that recalculation of transect-sampled areas was complex. In addition, using a narrower width would exclude even more of the valuable detections from tree islands (some of which were already excluded because transects did not come within 75 m of all the tree islands).

No attempts were made to analyze variation in detections at distances less than 50 m because there was little confidence in the recorded distances to singing birds in Old-Growth Control areas: most birds were only heard and there was found to be considerable inter-observer differences in distance estimates to birds that were only heard. This may partially account for the peak numbers of bird detections at distances 11-30 m from the transect line rather than at the transect line.

To calculate detection densities of individual species, all detections of a species on all the transects within a replicate were summed, and then divided by the total area sampled within the replicate. The total area sampled was the product of the sampling area in the replicate and the number of survey rounds. Densities had to be calculated from detection abundances because the sampling area in each replicate was different and because 12 survey rounds were not completed on some transects. The Emlen (1971) method that was used as the model for this study cannot be used to estimate absolute densities unless correlated with concurrent spot-mapping. While referred to hereafter as densities, these are in fact relative densities of birds detected per unit area rather than densities of territories as would be calculated from spot-mapping. Because different bird species will have different detectabilities, between species comparisons are not appropriate with this data. For notational convenience, the densities are expressed as birds detected per 100 ha.

To test for a possible source of error arising from differing sizes of replicates, analysis-of-covariance (ANCOVA) was applied with treatments as a fixed factor and sampled area as a covariate (Table 3). If area varies too greatly, then there is no basis for using species counts as a measure of diversity. Area had no significant effect as a covariate on total densities or richness, probably because the sampled areas varied over a fairly narrow range (16.1-34.9 ha).

Table 3. ANCOVA of sampled area as a covariate on total breeding bird densities and species richness. Full ANOVA statistics in Tables 5 and 6.

	Mean Square of Covariate (Area)	$F_{1,7}$	P
Singing Birds			
Total Density	12.68	0.09	0.77
Richness	2.09	0.24	0.64
All Birds Detected			
Total Density	59.93	0.09	0.78
Richness	1.29	0.05	0.82

3.4.2 Within Treatment Comparisons

Analyses within treatments were largely frustrated because of the extremely unbalanced transect sampling design as previously cited. Given a more balanced sampling design, the variation within treatments may still be of interest in future years of this study, but they are of secondary interest to the differences between treatments.

Bird activity as it varied with date (survey round) was examined solely to provide guidance for planning upcoming surveys to determine the most efficient time to sample for different species. Within the study area, breeding of any single species was probably very synchronous and any bias should be equal between experimental blocks. Each survey round is also a non-independent sample from other survey rounds (since many of the same birds are being counted again) and therefore, if analyzed, a within-treatment repeated measures design would have been necessary. This would have made the analyses considerably more complex without providing any more statistical power to the between treatment comparisons that were of real interest.

3.4.5 Completely Randomized vs. Randomized Block Design

The study design was a randomized block design with each treatment assigned only once to each experimental cutblock. However, if species densities and the factor effects were consistent between experimental blocks, then the randomized block design would have been less efficient than a completely randomized design because the blocking uses up 2 degrees of freedom—and with only 11 total degrees of freedom, removing a further 2 error degrees of freedom can significantly lower the power of the experiment. The relative efficiency of blocking was therefore examined to see if it was necessary to include in the analysis.

The relative efficiency of blocking was determined as recommended by Montgomery (1991:145) for total densities, richness and for species with >20 detections in the experimental blocks (Table 4). For most species, very little of

Table 4. Relative efficiency of Randomized Block Design compared to Completely Randomized Design. Full ANOVA statistics in Tables 5 and 6.

Species	Mean Square Error in Randomized Block Design	Mean Square due to Block Factor	Relative Efficiency of Blocking (R)[1]
ALL DETECTIONS			
All Woodpeckers	2.27	3.19	0.97
Tree Swallow	0.90	2.94	1.28
Red-breasted Nuthatch	0.66	1.97	1.23
Mountain Bluebird	0.23	0.31	0.97
Total Density (all sp.)	775.13	134.12	0.77
Richness	23.14	15.25	0.85
BIRDS ANALYZED USING SINGING DETECTIONS ONLY			
Swainson's Thrush	2.88	1.12	0.81
American Robin	2.48	2.43	0.90
Yellow-rumped Warbler	2.70	0.36	0.76
Wilson's Warbler	1.96	1.86	0.90
Chipping Sparrow	17.78	3.39	0.77
Savannah Sparrow	6.20	10.81	1.03
Lincoln's Sparrow	32.44	23.08	0.86
Dark-eyed Junco	14.53	41.82	1.22
Total Density (all sp.)	160.20	10.50	0.75
Richness	7.56	8.33	0.92

[1] $R < 1$ indicates greater efficiency of Completely Randomized Design,
$R = 1$ indicates equal efficiency of the designs,
$R > 1$ indicates greater efficiency of Randomized Block Design.

the error apparently originated in between-block density differences so that blocking of the design was less efficient. Therefore the completely randomized design was used for the rest of the analyses with each replicate of each treatment considered randomly chosen. Only for the Red-breasted Nuthatch, Tree Swallow, Savannah Sparrow and Dark-eyed Junco was the randomized block model more efficient. Additional analyses to attempt to account for this difference were done for the Red-breasted Nuthatch and Tree Swallow since they were found to be affected by the factors under study here and were of primary interest because they were also cavity nesters.

3.4.4 Between Treatment Comparisons

A 2x2 ANOVA model was used to determine factor and interaction effects on bird densities and richness. Generalized Linear Model (GLM)-ANOVA was used, although the results would not be expected to be different from unweighted means ANOVA because the number of replicates within each cell was equal. ANOVA is relatively robust to heterogeneity of variances when the numbers of replicates per cell are equal (Maxwell and Delaney 1990:703), so this was not tested. Tables of means include sample standard errors for each mean, even though ANOVA models use a pooled variance technique. Normality assumptions could not be assessed with only 3 replicates per cell.

Analyses were done species-by-species for any species that had >9 detections in the experimental blocks. This was fewer total detections than might normally be included in a study of this nature (typical cut-off point for species inclusion is 30 detections) but, since this analysis was exploratory, they have been included here for better assessment of the appropriate sample sizes for individual species analysis. For the species-by-species analysis, singing detections were used for most songbirds, but all detections used for finches, corvids and cavity-nesters[1]. All detections were used for woodpeckers to increase the sample size because the peak of woodpecker drumming activity occurred before the sampling period. Effect size (f of Cohen 1988, where $f = 0.1$ for small effect size, $f = 0.25$ for medium effect size and $f = 0.4$ for large effect size), probability of statistical significance (probability of a Type I error) and statistical power (1 minus the probability of a Type II error) were also estimated for each between treatment comparison. Alpha levels of 0.05 were used to test for main effects significance and 0.10 for interaction effects to keep the power approximately equivalent to the main effects tests.

[1]Winter Wrens often nest in cavities in upturned root masses, stumps or logs, and are therefore cavity-nesters (Harrison 1979). However, they do not usually nest in trees and are best sampled by song counts, so have been included with the songbirds in this report rather than with the cavity-nesters.

5.4.5 *Treatment-to-Control Comparisons*

The Old-Growth Control units were compared to the treatments using Dunnett's Procedure (Dunnett 1955) which compares treatment means individually to the control mean. This test is more powerful for a given level of significance than other multiple-means comparisons because fewer total comparisons are made. This procedure uses a joint significance level which is set at alpha equals 0.05 for this study. Comparisons were made for those species with >9 detections. This is fewer total detections then might be normally be included in such an analysis but, since this analysis is exploratory, have been included here to assist in the evaluation of the number of detections needed to detect significant differences between Old-Growth and cutblock treatments. Effect sizes and statistical power were not readily available for Dunnett's Procedure.

3.4.6 *Bird Communities*

The power of bird community macroparameters to provide insight into community processes is usually not very good except to sometimes highlight species groups deserving further study (Wiens 1989b:257). Therefore considerations of diversity indices were not emphasized here. The only macroparameters considered were total densities for all species combined, and species richness (S)—the simple count of the number of species encountered in a treatment unit. Since the number of species counted may be highly correlated with the numbers of individual birds detected in a given area, the regression of richness with densities was examined. A log-log model ($S = kA^z$, where A = Area and k and z are fitted constants) was used for this regression since this usually provides the best fit for species-area regressions (Wiens 1989a:103), even though, in this case, density rather than area was being examined.

Analyses were not made for cavity-nesting birds as a group in most instances because initial analysis showed that individual cavity-nesting species reacted quite differently to the treatments. Consequently, considering them as a single group tended to mask, rather than clarify, trends in the data. Only woodpeckers were considered as a group because of the relatively high percentage (24 %) of woodpecker detections that could not be identified to species. All the unidentified woodpecker detections in the cutblocks were made in tree islands. This was a significant bias in the sampling method, i.e. woodpeckers could be positively identified if they were in clearcuts because they could be easily seen, but could not be positively identified within tree islands (or Old-Growth Controls). Consequently, even though different species of woodpeckers do have different habitat requirements and preferences, they were grouped together here for analysis.

A hierarchical clustering procedure (Simple Averaging) provided a graphical comparison of bird community similarities between treatment units and Old-Growth Controls. First, Euclidean Distance (van Tongeren 1987) was used which is sensitive to species composition and abundance as well as to dominant species. Second, the Jaccard Index (van Tongeren 1987) was used which took into account only species composition based on presence/absence data (single weight to common presences between units/total number of species in the units).

3.4.7 Habitat Feature Use

For analysis, only "snags" and tree islands were separated as habitat features because these were the only ones of experimental interest here. All other detections were lumped under "Other". This included debris piles, ground, young conifers, flying birds (but not birds in overflight that were excluded from all analyses), and the 12% of bird detections for which no habitat feature was recorded. Each detection of a bird, or group of birds, was considered one detection for analysis of habitat features. There was potentially a large amount of subjective bias that could have been introduced using the detectional method chosen, particularly in terms of the length of time individual birds were followed, possible reactions to the observers and which activities were given priority. It was not possible to measure the potential for bias at the analysis stage since first detected activities were not separated from subsequent ones so that this data must be interpreted with caution. Bird use of habitat features were not analyzed for factor and interaction effects using the 2x2 ANOVA model because of these unknown biases. In addition, since the two habitat features analyzed were also the main effects analyzed in the 2x2 ANOVA, any significant results may have been trivial because of autocorrelation.

The transect methods were developed for relatively uniform habitat (Emlen 1971), and tree islands within a clearcut create habitat heterogeneity rather than uniformity. Initial data scanning revealed a very high proportion of detections from the TI and SI treatments were coming from the tree islands. Analysis of the islands as part of the entire treatment unit was too coarse to show their real significance. Tree island sizes were not accurately measured so that bird densities within them could not be calculated. For individual species detected >9 times in the experimental blocks, the proportion of detections in tree islands were compared using Chi-square to the expected proportion. The expected proportion used for tree island detections was 10% of the total detections for individual species. The tree islands actually occupied closer to 3% of the experimental block area but because of possible bias introduced by recording birds as being in tree islands when they were first detected outside, but then flew into the tree islands while being watched, 10% has been used to be conservative.

The effects of tree islands were also examined by excluding detections made within the tree islands and recalculating total densities of singing birds and of all birds. This determined what portion of the total densities in the TI and SI Treatments were due to detections made within the tree islands, and whether the densities of the "clearcut" areas surrounding the tree islands were similar to the CC and SB Treatments.

To measure the relative importance of stubs to different species, the numbers of detections of birds in the experimental blocks outside of tree islands were totalled and separated into those not detected on "snags" and those detected on "snags" and the proportions compared using Chi-square. Analyses were first done comparing cavity-nesting birds as a group to other birds, and then for cavity-nesting species separately from other species. Only species for which the expected cell values were >5 were included separately, all other species were grouped.

3.4.8 Chronology of Breeding Activities

The detection of singing males is key to almost all methods of breeding bird surveys and timing of the surveys must coincide with peaks of singing to accurately measure territorial bird activity. The singing and other breeding activities found in 1993 were analyzed to set future sampling dates at the most efficient times. For the 6 most common species, and for all cavity-nesters, the numbers of singing males encountered per survey round were tallied and graphed for comparisons. Incidental detections made of breeding activities were also included on the graphs.

4.0 RESULTS

4144 bird detections were made in cutblock treatments and used in the analyses, and 2732 in Old-Growth Controls. 63 species of birds were recorded in the cutblock treatments and Old-Growth Controls (see Appendices A and B).

Six cavity-nesting species accounted for 95.5% of the 355 detections of cavity-nesting birds: the Brown Creeper was confined to the Old-Growth areas; the Mountain Bluebird and Tree Swallow were confined to the cutblock treatment areas; and the Red-breasted Nuthatch, Black-backed Woodpecker, and Three-toed Woodpecker were found in both areas. In addition, 30 detections were made of woodpeckers that could not be identified to species. These detections were either of Three-toed or Black-backed Woodpeckers. Five other cavity-nesting species were recorded fewer than 9 times each: the Boreal Chickadee, Mountain Chickadee, Northern Flicker and Pileated Woodpecker, were recorded less than 3 times each and the American Kestrel only 8 times. These uncommon species could not be included in the species-by-species analysis, and no evidence was found that any of these nested in the experimental cutblocks or Old-Growth Control areas.

4.1 Stub and Tree-Island Effects

Fourteen singing bird species, 4 other bird species and 4 cavity-nesting species (or group of species for woodpeckers) had >9 detections in the treatments and were analyzed for between treatment differences in mean densities. Significant interaction effects between stubs and tree islands were found for the Olive-sided Flycatcher, the Yellow-rumped Warbler, the Mountain Bluebird and for woodpeckers as a group (Tables 5 and 6). The effects were positive for all these species except the Mountain Bluebird, i.e. both stubs and tree islands when combined in a treatment resulted in higher densities than for the additive effects of either property alone. For the Mountain Bluebird, the interaction effect was negative and they were never detected in the SI Treatment that combined stubs with tree islands.

Stubs only had significant effects on the densities of Olive-sided Flycatchers, Tree Swallows and woodpeckers as a group (Tables 5 and 6). No other species showed significant responses to stubs although many birds used them for perching or foraging when they were available (see Habitat Features below).

Tree islands had significant positive effects on 6 species as well as woodpeckers as a group (Tables 5 and 6). These species were: Olive-sided Flycatcher, Swainson's Thrush, Yellow-rumped Warbler, Blackpoll Warbler, Wilson's Warbler and Red-breasted Nuthatch. Only for Mountain Bluebirds was there a significant negative response. Tree islands also had significant positive effects on Total Densities and Richness of both singing birds (Table 5) and all birds detected (Table 6).

Table 5. Mean treatment densities and 2x2 ANOVA table of stub and tree island effects for singing bird species with >9 singing detections in the treatments.

Species	Mean Density of Detections ± S.E. (Number/100 ha) n = 3 for each cell		Effect	Test Statistics				
	Stubs (S)	Tree Islands (I) Absent	Present		Mean Square	$F_{1,8}$	P (α)	Effect Size	Power (1-β)
Seasonal Bird Species									
Olive-sided Flycatcher	Abs.	0.1 ± 0.1	0.6 ± 0.2	S	0.63	6.51	.03	.74	.54
				I	3.07	31.90	.00	1.63	.99
	Pres.	0	1.6 ± 0.3	S*I	1.02	10.65	.01	.94	.86
Western Wood pewee	Abs.	0	0.4 ± 0.2	S	0.53	0.48	.51	.20	.09
				I	1.81	1.64	.24	.37	.18
	Pres.	0	1.2 ± 1.2	S*I	0.53	0.48	.51	.20	.16
Ruby crowned Kinglet	Abs.	0	0.9 ± 0.8	S	0.20	0.34	.57	.17	.08
				I	1.33	2.34	.16	.44	.23
	Pres.	0	0.4 ± 0.3	S*I	0.20	0.34	.57	.17	.14
Swainson's Thrush	Abs.	0	1.9 ± 0.7	S	0.82	0.53	.49	.21	.09
				I	17.77	11.40	.01	.97	.77
	Pres.	0	3.0 ± 1.2	S*I	0.82	0.53	.49	.21	.10
American Robin	Abs.	2.3 ± 0.9	7.3 ± 1.0	S	0.21	0.08	.78	.08	.06
				I	5.24	2.12	.18	.42	.22
	Pres.	1.3 ± 0.1	3.9 ± 1.4	S*I	5.01	2.03	.19	.41	.32
Yellow-rumped Warbler	Abs.	2.4 ± 1.2	7.0 ± 1.1	S	0.35	0.16	.70	.12	.06
				I	130.77	61.95	.00	2.27	.99
	Pres.	0.7 ± 0.2	9.4 ± 0.5	S*I	12.48	5.91	.04	.70	.65
Townsend's Warbler	Abs.	0	1.4 ± 1.1	S	0.18	0.18	.68	.12	.06
				I	4.25	4.27	.07	.60	.39
	Pres.	0	0.9 ± 0.2	S*I	0.18	0.18	.68	.12	.12
Blackpoll Warbler	Abs.	0	0.8 ± 0.5	S	0.10	0.42	.53	.19	.15
				I	1.30	5.73	.04	.89	.99
	Pres.	0	0.5 ± 0.3	S*I	0.10	0.42	.53	.19	.20
Wilson's Warbler	Abs.	0	5.6 ± 0.2	S	2.58	1.34	.23	.43	.16
				I	119.71	62.01	.00	2.27	.99
	Pres.	0.2 ± 0.2	7.2 ± 1.6	S*I	1.71	0.89	.37	.27	.20
Chipping Sparrow	Abs.	7.0 ± 2.4	10.5 ± 2.5	S	6.65	0.47	.51	.20	.09
				I	43.68	3.09	.12	.51	.30
	Pres.	5.1 ± 0.9	9.3 ± 2.5	S*I	0.33	0.02	.89	.04	.10
Savannah Sparrow	Abs.	3.8 ± 2.9	0.6 ± 0.4	S	4.50	0.61	.46	.23	.10
				I	13.22	1.80	.22	.39	.19
	Pres.	1.4 ± 0.9	0.5 ± 0.5	S*I	4.10	0.56	.48	.22	.17

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Table 5. Continued from previous page.

Species	Mean Density of Detections ± S.E. (Number/100 ha) n = 3 for each cell		Effect	Test Statistics				
	Strata (S)	Tree Islands (I) Absent	Present		Mean Square	$F_{s,t}$	P (α)	Effect Size	Power (1-β)
SINGING BIRD SPECIES									
Lincoln's Sparrow	Abs.	8.1±3.5	13.2±3.3	S	18.23	0.61	.46	.23	.10
				I	41.44	1.38	.27	.34	.16
	Pres.	11.9±2.3	14.3±3.5	S*I	5.67	0.19	.68	.13	.12
White-crowned Sparrow	Abs.	0	0.7±0.3	S	0.12	0.22	.65	.14	.07
				I	1.88	3.41	.10	.53	.32
	Pres.	0.1±0.1	1.0±0.8	S*I	0.04	0.08	.78	.05	.11
Dark-eyed Junco	Abs.	12.7±0.1	14.0±3.3	S	31.67	1.43	.26	.35	.16
				I	1.85	0.09	.78	.09	.06
	Pres.	17.1±1.1	16.8±4.1	S*I	3.47	0.16	.70	.12	.12
COMMUNITY MACROPARAMETERS									
Total Density (all species)	Abs.	37.5±6.3	66.2±6.3	S	167.52	1.36	.28	.34	.19
				I	3313.00	26.98	.00	1.50	.98
	Pres.	40.4±4.6	78.2±8.0	S*I	61.88	0.50	.50	.20	.16
Richness	Abs.	7.3±0.7	20.7±2.0	S	16.33	2.11	.18	.42	.22
				I	363.00	46.84	.00	1.08	.99
	Pres.	12.0±0.6	20.7±2.3	S*I	16.33	2.11	.18	.42	.34
Total Density (excl. detections from tree islands)	Abs.	37.5±6.3	39.2±2.6	S	0.73	0.01	.92	.25	.12
				I	1.49	0.02	.88	.27	.12
	Pres.	40.4±4.6	37.7±3.5	S*I	17.83	0.30	.60	.22	.17

Table 6. Mean treatment densities and 2x2 ANOVA table of stub and tree island effects for cavity-nesting bird species and for other bird species with >9 detections in the treatments.

Species	Mean Density of Detections ± S.E. (Number/100 ha) n = 3 for each cell		Effect	Test Statistics				
	Stubs (S)	Tree Islands (I) Absent	Present		Mean Square	$F_{1,8}$	P (α)	Effect Size	Power (1-β)
CAVITY-NESTING BIRD SPECIES									
All Woodpeckers	Abs.	0.6±0.3	1.6±1.0	S	15.65	6.26	.04	.72	.52
				I	26.64	10.66	.01	.94	.74
	Pres.	0.9±0.6	5.8±1.3	S*I	11.71	4.69	.06	.63	.57
Tree Swallow	Abs.	0.3±0.1	0.1±0.1	S	25.12	17.83	.00	1.22	.92
				I	0.25	0.18	.68	.12	.06
	Pres.	2.7±1.1	3.5±0.7	S*I	0.55	0.39	.55	.18	.15
Red-breasted Nuthatch	Abs.	0	1.6±0.9	S	0.03	0.03	.88	.05	.05
				I	8.78	8.87	.02	.86	.66
	Pres.	0	1.6±0.7	S*I	0.03	0.03	.88	.05	.10
Mountain Bluebird	Abs.	0.8±0.5	0.7±0.2	S	0.00	0.00	.96	.00	.05
				I	1.80	7.13	.03	.77	.57
	Pres.	1.5±0.0	0	S*I	1.48	5.87	.04	.70	.65
OTHER BIRD SPECIES									
Gray Jay	Abs.	0.1±0.1	0.5±0.3	S	0.11	0.45	.52	.19	.08
				I	1.20	4.75	.06	.63	.42
	Pres.	0.1±0.1	1.0±0.5	S*I	0.18	0.69	.43	.24	.18
Pine Grosbeak	Abs.	0.3±0.3	0.3±0.2	S	0.09	0.37	.56	.18	.08
				I	0.70	2.84	.13	.49	.28
	Pres.	0	0.9±0.5	S*I	0.55	2.22	.17	.43	.35
Red Crossbill	Abs.	1.5±1.5	0.5±0.5	S	0.64	0.26	.62	.15	.07
				I	0.02	0.01	.94	.03	.05
	Pres.	0.1±0.1	1.0±0.8	S*I	2.68	1.10	.32	.30	.22
Pine Siskin	Abs.	5.8±3.8	23.5±15.3	S	66.39	0.28	.52	.15	.07
				I	264.42	1.12	.32	.31	.14
	Pres.	9.4±6.0	10.5±5.6	S*I	205.08	0.87	.38	.27	.20
COMMUNITY MACROPARAMETERS									
Total Density (all species)	Abs.	97±10	157±18	S	997.27	1.62	.24	.37	.18
				I	12060.59	19.61	.00	1.28	.94
	Pres.	113±11	179±17	S*I	19.36	0.03	.86	.05	.10
Richness	Abs.	12.7±2.3	25.3±3.2	S	12.00	0.57	.47	.22	.09
				I	533.33	25.20	.00	1.45	.98
	Pres.	17.0±1.5	28.0±3.2	S*I	16.33	0.77	.41	.25	.18
Total Density (excl. detections from tree islands)	Abs.	97±10	111±15	S	196.4	0.59	.47	.20	.09
				I	145.4	0.44	.53	.21	.09
	Pres.	113±11	112±4.4	S*I	173.3	0.52	.49	.20	.16

Table 7. Tree Swallow and Red-breasted Nuthatch Treatment Unit densities and randomized block 2x2 ANOVA statistics for stub and tree island effects.

Species	Density of Detections (Number/100 ha)				Effect	Test Statistics					
	Block (B)	Stubs (S)	Tree Islands (I)			df	Mean Square	F	P (α)	Effect Size	Power (1-β)
			Abs.	Pres.							
Tree Swallow (All Detections)	5516	Abs.	0.4	0	S	1	25.12	27.97	.00	1.53	.95
		Pres.	2.8	4.5	I	1	0.25	0.28	.62	.15	.07
	5546	Abs.	0.5	0.4	S*I	1	0.54	0.61	.47	.23	.16
		Pres.	4.7	3.8	B	2	2.94	3.28	.11	.52	
	5547	Abs.	0	0	Error	6	0.90				
		Pres.	0.7	2.1	C.R. Error[1]	8	1.47				
Red-breasted Nuthatch (All Detections)	5516	Abs.	0	3.4	S	1	0.03	0.04	.85	.06	.05
		Pres.	0	3.3	I	1	5.78	13.21	.01	1.05	.70
	5546	Abs.	0	0.9	S*I	1	0.03	0.04	.85	.06	.10
		Pres.	0	1.1	B	2	1.92	2.36	.13	.50	
	5547	Abs.	0	0.6	Error	6	0.66				
		Pres.	0	1.0	C.R. Error[1]	8	0.99				

[1]Completely Randomized Design Error included for comparative purposes.

4.2 Additional Analyses for Red-breasted Nuthatches and Tree Swallows.

As already shown (sec 3.4.3, Table 4), the randomized block design was more efficient for Red-breasted Nuthatches and for Tree Swallows than the completely randomized design. For both species, Block effect sizes were large (0.50-0.52) but not significant. For the Red-breasted Nuthatch, the randomized block design was more efficient because of the uneven dispersion of detections between blocks: a disproportionately high (although not significantly higher) number of detections came from Block 5516 (Table 7). Examination of the actual locations (Figure 3) showed that 18 of the 27 detections of Red-breasted Nuthatches in the blocks came from Block 5516, with 8 of these detections coming from the single largest (1-ha) tree island.

For the Tree Swallow, this high (but again not significant) inter-block variability resulted from a lower number of detections coming from Block 5547 (Table 7). Examination of actual locations of detections (Figure 4) indicated that overall detections were clustered within Blocks 5516 and 5546, particularly near locations of possible nests. No Tree Swallow nesting activity was observed in Block 5547 (see Incidental Observations below).

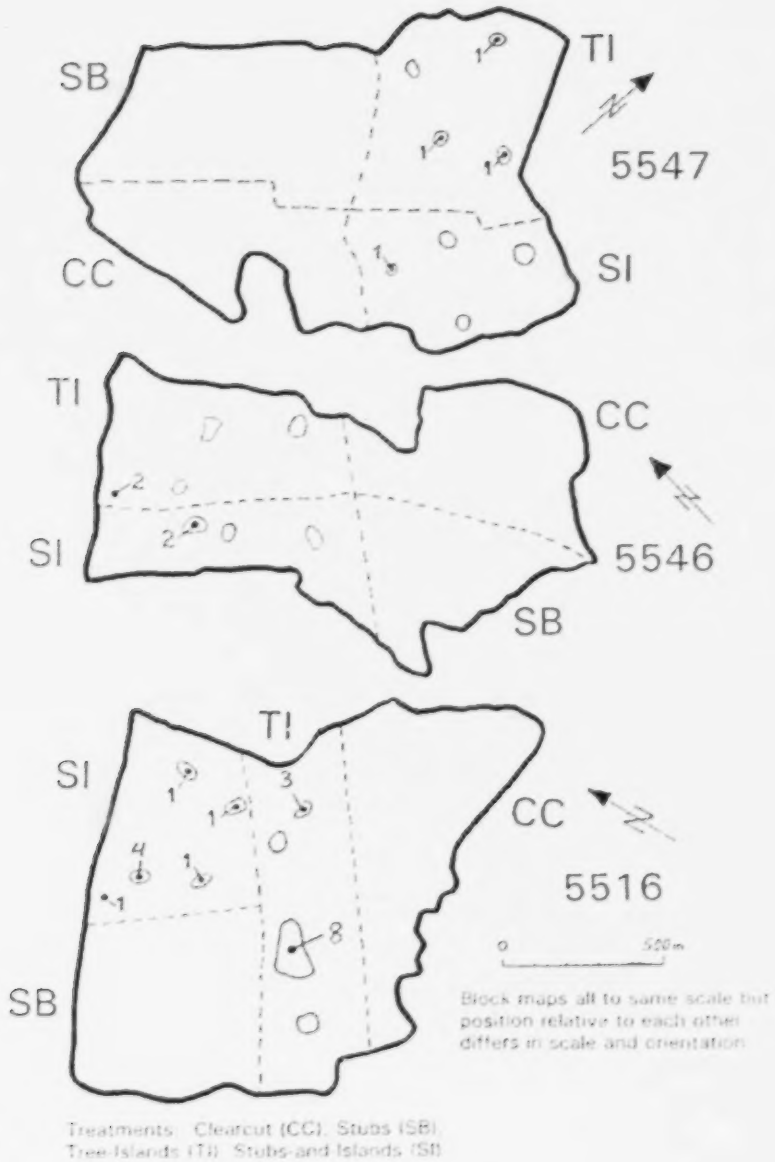

Figure 3. Red-breasted Nuthatch detection locations (•) in the Treatment Units of Blocks 5516, 5546 and 5547 of the Donna Creek Study Area, B.C.

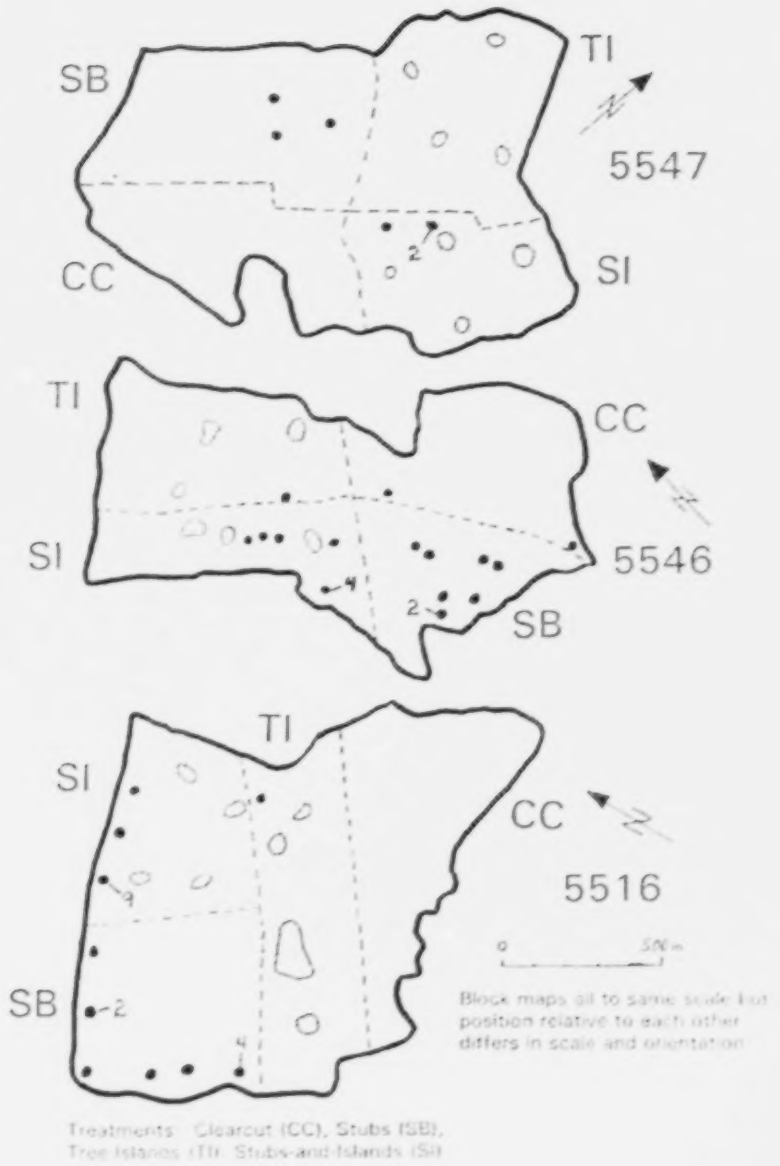

Figure 4. Tree Swallow detection locations (•) in the Treatment Units of Blocks 5516, 5546 and 5547 of the Donna Creek Study Area, B.C.

4.3 Old-Growth to Treatment Comparisons

Nineteen singing bird species, 7 other species and 5 cavity-nesting species (or groups) had >9 total detections and were analyzed for differences in means between Old-Growth Controls and treatments. The Winter Wren, Golden-crowned Kinglet, Ruby-crowned Kinglet, Swainson's Thrush, Varied Thrush, Tennessee Warbler, Yellow-rumped Warbler, Townsend's Warbler, Blackpoll Warbler, Wilson's Warbler, Red-breasted Nuthatch, Brown Creeper, Spruce Grouse and Gray Jay all had higher densities in the Old-Growth Control forests than in any of the treatments (Tables 8 and 9). No species had significanTly higher densities in all of the treatments than in the Old-Growth Controls even for Tree Swallows, Mountain Bluebirds, Savannah Sparrows, and White-crowned Sparrows that were never detected in the Old-Growth Controls. SignificanTly higher densities were found in some of the treatments for Olive-sided Flycatchers, Lincoln's Sparrows, Dark-eyed Juncos, Tree Swallows and Mountain Bluebirds. The Pine Siskin only had significanTly lower densities than the Old-Growth Controls in the CC and SB treatments that lacked tree islands.

Total densities, both of all singing birds and of all birds detected, were significanTly lower in all of the treatments than in the Old-Growth Controls. Richness of singing birds was significanTly lower in all of the treatments than in the Old-Growth Controls but, when counting all species using all detections, richness was only significanTly lower only in the CC and SB treatments.

4.4 Bird Communities

Cluster analysis indicated that the bird communities of the Old-Growth Controls were very dissimilar to the treatment units. When densities were used, two very distinct clusters formed (Figure 5A). The Old-Growth controls were more similar to each other than to any of the treatment units. Within the treatment units containing tree islands (TI and SI), initial clusters with the greatest similarities were between treatment units of the same cutblock. These first within-block clusters were more similar to each other than to the treatment units without tree islands (CC and SB). Initial clustering within the group of CC and SB units was not along Block lines but appeared more random.

Cluster analysis using only presence/absence data (Figure 5B) showed quite a different pattern. The tree island treatment units (TI and SI) were closer in similarity to the Old-Growth Controls than the treatment units without tree islands (CC and SB). The CC treatment units formed an initial cluster, and then SB treatments were joined incrementally to the cluster without forming a cluster of their own. For the TI and SI treatment units, initial clustering was within the same blocks for 5516 and 5547 but not for 5546 which was added incrementally to Block 5547. The Old-Growth Controls formed an initial cluster to which the TI and SI treatment units were added at lower levels of similarity.

Table 8. Old-Growth Control to treatment comparisons of mean densities for singing bird species with >9 singing detections.

Species	Mean Density ± S.E. (Detections/100ha)	Difference in Treatment Means relative to Old-Growth[1]				Test Statistics[2]	
	Old Growth Controls	CC	SB	TI	SI	MS_E 10 d.f.	d
SINGING BIRD SPECIES							
Olive-sided Flycatcher	0.7 ± 0.2	o	o	o	-	0.09	0.72
Western Wood-Pewee	0.7 ± 0.5	o	o	o	o	1.04	2.41
Hammond's Flycatcher	2.3 ± 1.7	o (0)	o (0)	o (0.1)	o (0)	1.64	3.02
Winter Wren	6.2 ± 1.2	(0)	(0)	(0.1)	(0.3)	0.93	2.28
Golden-crowned Kinglet	20.2 ± 2.1	(0)	(0)	(0.4)	(0.5)	2.80	3.95
Ruby-crowned Kinglet	6.6 ± 0.8	-			-	1.34	2.73
Swainson's Thrush	26.9 ± 4.6					23.05	11.32
American Robin	5.5 ± 2.1	o	o	o	o	4.60	5.06
Varied Thrush	7.6 ± 1.6	(0)	- (0)	(0.1)	- (0.1)	1.51	2.90
Tennessee Warbler	1.4 ± 0.5	(0)	- (0)	(0.1)	- (0)	0.18	1.01
Yellow-rumped Warbler	33.4 ± 2.1					4.36	4.93
Townsend's Warbler	76.5 ± 5.8					34.90	13.94
Blackpoll Warbler	17.5 ± 2.6					7.21	6.34
Wilson's Warbler	18.0 ± 2.4					8.47	6.86
Chipping Sparrow	14.5 ± 1.7	o		o	o	13.06	8.53
Savannah Sparrow	0	o	o	o	o	5.88	5.72
Lincoln's Sparrow	0.1 ± 0.1	o	+	+	+	24.09	11.58
White-crowned Sparrow	0	o	o	o	o	0.44	1.57
Dark-eyed Junco	3.6 ± 1.2	o	+	+	+	17.90	9.98
COMMUNITY MACROPARAMETERS							
Total Density (all species)	270 ± 12					180.53	31.71
Richness	28.0 ± 1.2					7.00	6.24

[1]Treatment means in parentheses are only provided for species not listed in Table 5.
- indicates mean density is significantly lower than Old-Growth Control,
o indicates mean density not significantly different from Old-Growth Control,
+ indicates mean density is significantly greater than Old-Growth Control.

[2]MS_E is Mean Square Error of one-way ANOVA with 5 levels each with 3 replicates,
d is Dunnett's critical difference level expressed in densities for direct use in the table.

Table 9. Old-Growth Control to treatment comparisons of mean densities of cavity-nesting species and other species with >9 total detections.

Species	Mean Density of Detections ± S.E.	Difference in Treatment Means relative to Old Growth[1]				Test Statistics[2]	
	Old Growth Controls	CC	SB	TI	SI	MS_E 10 d.f.	d
CAVITY NESTING BIRD SPECIES							
All Woodpeckers	8.6 ± 4.0	o	o	o	o	11.53	8.01
Tree Swallow	0	o	+	o	-	1.13	2.51
Red-breasted Nuthatch	13.8 ± 2.0	-				3.12	4.17
Brown Creeper	2.7 ± 0.5	(0)	(0)	- (0)	- (0)	0.15	0.91
Mountain Bluebird	0	o	+	o	-	0.20	1.06
OTHER BIRD SPECIES							
Spruce Grouse	1.2 ± 0.2	(0)	(0.1)	(0.1)	(0.1)	0.05	0.53
Gray Jay	4.3 ± 0.2	-				0.22	1.11
Pine Grosbeak	0.7 ± 0.5	o	o	o	o	0.35	1.40
Red Crossbill	1.7 ± 1.0	o	o	o	o	2.51	3.74
White-winged Crossbill	3.8 ± 0.8	(0)	- (0.3)	- (0.1)	- (0.1)	0.46	1.60
Pine Siskin	23.2 ± 4.1	-		o	o	199.18	33.30
Evening Grosbeak	3.0 ± 1.0	(0)	(0)	(0.2)	(0.5)	0.66	1.91
COMMUNITY MACROPARAMETERS							
Total Density (all species)	369 ± 17					659.85	60.61
Richness	31.0 ± 0.6	-	-	o	o	17.13	9.77

[1]Treatment means in parentheses are only provided for species not listed in Table 6.
- indicates mean density is significantly lower than Old-Growth Control,
o indicates mean density not significantly different from Old-Growth Control,
+ indicates mean density is significantly greater than Old-Growth Control.

[2]MS_E is Mean Square Error of one-way ANOVA with 5 levels,
d is Dunnett's critical difference level expressed here in densities for direct use in the table.

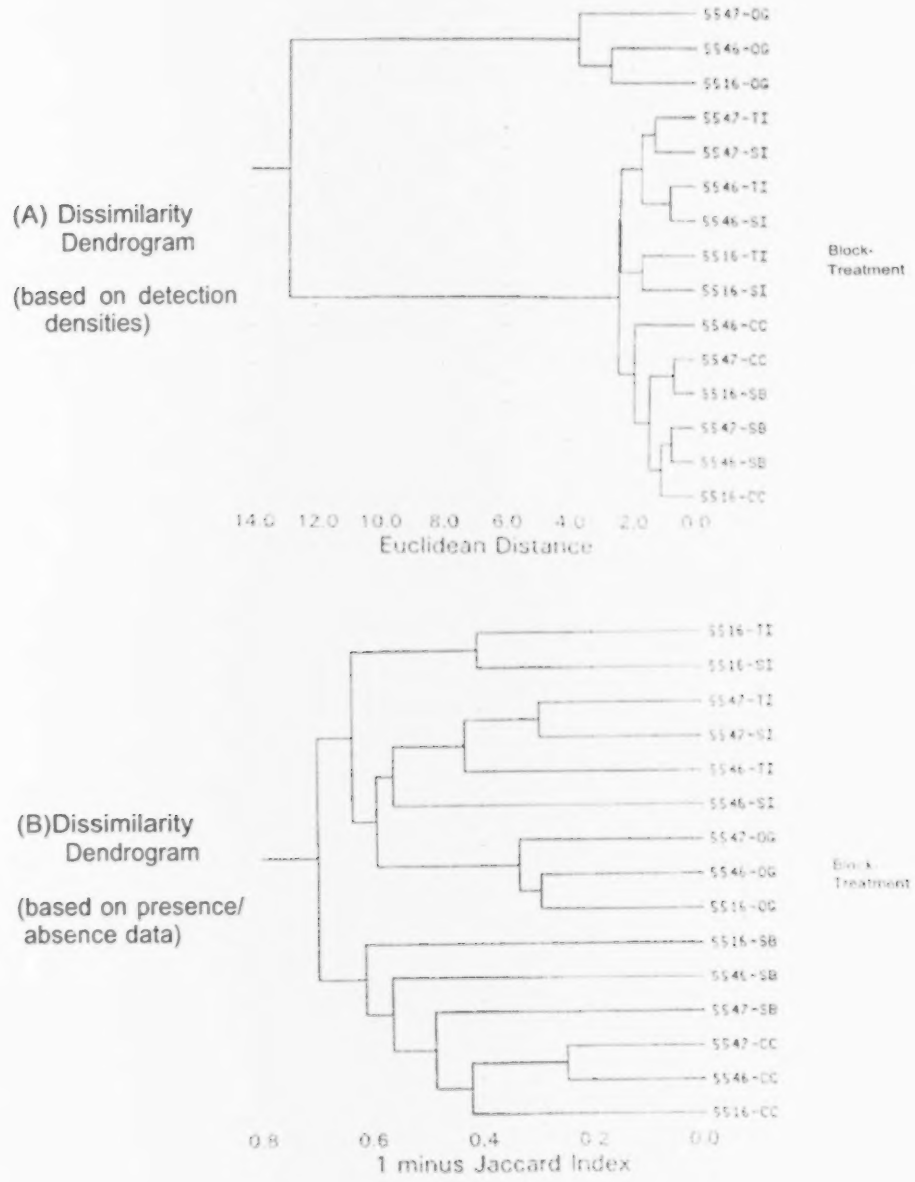

Figure 5. Dendrograms from Simple Average cluster analysis of Treatment Units and Old-Growth Controls using (A)Euclidean Distance on singing bird detection densities, and (B)the Jaccard Index on singing bird presence/absence data.

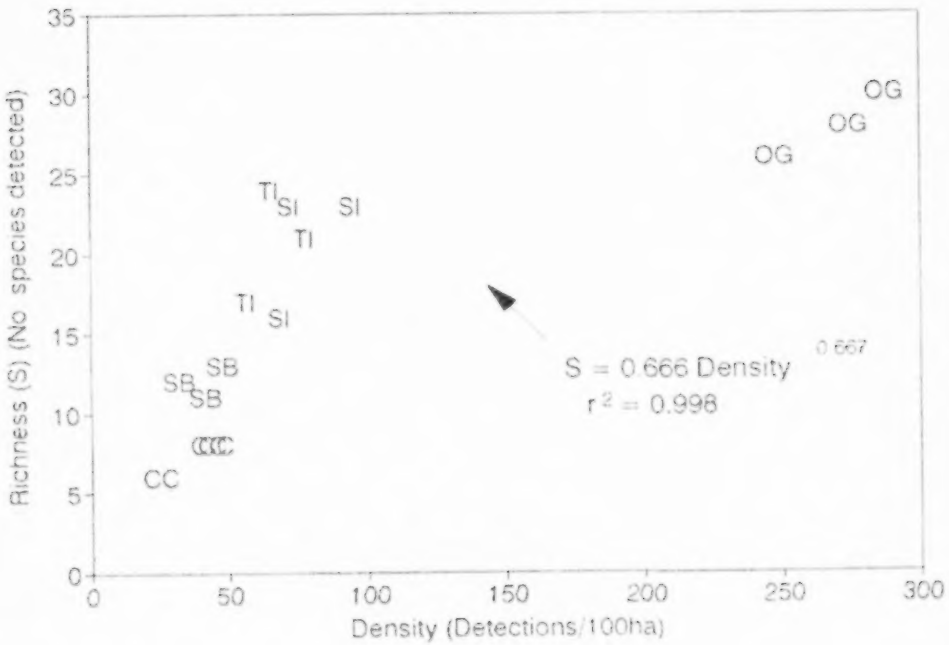

Figure 6. Regression of species richness on detection densities for Old-Growth Controls (OG) and Treatment Units (CC, SB, TI and SI). Regression line fitted for CC and OG points only.

Diversity was also examined as the relationship between bird detection density and species richness. Singing birds were used for this analysis because there was felt to be the least amount of bias in detecting singing birds compared to using all detections. The CC Treatment had the lowest number of species and number of birds detected (Figure 6). Creating stubs (SB Treatment) resulted in a slight increase in the number of species, without great increases in the densities of birds detected. Adding tree islands (TI and SI Treatments) resulted in roughly double the number of species and densities of birds detected found within a unit. Old-Growth Controls had much higher densities and only slightly higher richness than the TI and SI Treatments. The log-log regression using "untreated" units (i.e., CC and Old-Growth Controls) was calculated to compare to the alternative timber-harvesting treatments. The locations of each of the alternative timber-harvesting treatments was above this line indicating more species were present at a given bird density.

Table 10. Numbers of detections of bird species and groups of species outside of tree islands that were "on snags" (including stubs) and "not on snags".

Species[1]	Number Of Detections in Cutblocks		χ^2 Test Statistics		
			Cell wise Contribution		
	Not on Snags[2]	On Snags[2]	Not on Snags	On Snags	Total
ALL SPECIES					
Cavity-nesting Species	52	29	6.15	57.89	66.13
All Other Species	2273	218	0.20	1.88	$P < .05$
CAVITY NESTING SPECIES					
Tree Swallow	29	4	2.88	5.17	18.12
Black-backed Woodpecker	8	13	2.23	4.00	
Mountain Bluebird	11	5	0.05	0.09	
American Kestrel	1	5	1.32	2.38	
Red-breasted Nuthatch	1	2			
Mountain Chickadee	1	0			
Three-toed Woodpecker	1	0			
NON-CAVITY NESTING SPECIES					
Dark-eyed Junco	1005	116	0.31	3.26	30.11
Lincoln's Sparrow	515	32	0.50	5.26	
Chipping Sparrow	264	26	0.01	0.09	
American Robin	116	24	1.10	11.52	
Yellow-rumped Warbler	113	6	0.18	1.67	
Savannah Sparrow	62	4	0.05	0.59	
Pine Siskin	51	1	0.27	2.77	
Other Non-cavity nesters	158	9	0.21	2.16	

[1]Individual species ranked by abundance.
[2]Snags includes stubs as well as other retained, dead tree material standing upright, or almost upright.

4.5 Relative Use of Habitat Features

A wide variety of bird species used the stubs and "snags". Using only those detections of birds within the treatments but outside of tree islands, cavity-nesting birds were detected significantly more often on "snags" (which includes stubs) than non-cavity-nesting birds based on the expected proportion (Table 10). Examination of cavity-nesters separately indicated that Tree Swallows were detected on the "snags" significantly less often than other cavity-nesters while Black-backed Woodpeckers were detected more frequently. Among other common bird species, American Robins and Lincoln's Sparrows contributed the largest single amounts to the significant Chi-square statistic, with American Robins detected more often than expected and Lincoln's Sparrows less often than expected.

For 15 species, and for woodpeckers as a group, there was a significantly higher proportion of detections from within tree islands than would have been expected based on chance alone—even using the inflated 10% figure for total area of the tree islands which results in a very conservative test (Table 11). Only for the Savannah Sparrow was there a significantly lower proportion of detections from within tree islands because it was never detected within a tree island. No significant differences were found in proportions of detections within and outside tree islands for Lincoln's Sparrow, White-crowned Sparrow, Dark-eyed Junco, Tree Swallow and Mountain Bluebird.

The positive effect of tree islands on bird densities in clearcuts appeared to be limited largely to the areas of the tree islands themselves, without much "spillover" into the clearcut areas surrounding the tree islands. When the bird detections made within tree islands were removed from the data, and total bird densities recalculated in the treatments, the significant island effect ("I" in Tables 5 and 6 for Total Densities) changed and total densities were no longer significantly affected by tree islands.

4.6 Incidental Observations of Cavity Nesting

American Kestrel—One possible nest cavity was found on 5 June that was 130 m from the forest and 27 m from a tree island in the SI Treatment unit of Block 5546.

Woodpeckers—One Black-backed Woodpecker nest was discovered on 21 June, about 50 m from the forest edge in the CC Treatment unit of Block 5547. A pair were excavating a cavity in a green snag on 23 May about 40 m from the forest edge in the SB Treatment unit of Block 5516. A possible nest was discovered on June 24 about 100 m from the forest edge and 80 m from a tree island in the SI Treatment unit of Block 5516. A fourth possible Black-backed Woodpecker nest was discovered on 17 June within a tree island in the SI Treatment unit of Block 5546. A young Three-toed Woodpecker near the nest, along with the pair of adults, was found in the Old-Growth Control area adjacent to Block 5547 about 25 into the forest from the cutblock edge.

Tree Swallow—One possible nest was found on 15 May in a snag 280 m from the nearest forest edge, and 250 m from the nearest tree island, in the SB Treatment unit of Block 5546. A pair of Tree Swallows probably nested in the SI Treatment unit of Block 5516.

Chickadees—Chickadees were very uncommon in the area and were not breeding in the cutblocks or the sampled Old-Growth areas. Boreal Chickadees were only observed 3 times during sampling, and all were in Old-Growth Controls (one in each area). They were observed in mid-July and all were probably post-breeding dispersers from other areas. Only 2 Mountain Chickadees were observed in the treatment units and none in the Old-Growth Controls. Both Mountain Chickadees were seen in late-May in, or adjacent to, tree islands of Block 5516.

Table 11. Numbers of bird species detections within tree islands and outside of tree islands in treatments.

Species	Total Numbers of Bird Detections			Direction of Response to tree islands	P[2]
	Outside tree islands (1)	Within tree islands (2)	Total in treatments (1)+(2)		
Bird species analyzed using Signal detection only					
Olive-sided Flycatcher	5	11	16	+	.00
Western Wood-peewee	1	9	10	+	.00
Ruby-crowned Kinglet	0	12	12	+	.00
Swainson's Thrush	1	36	37	+	.00
American Robin	48	26	74	-	.00
Yellow-rumped Warbler	43	101	144	+	.00
Townsend's Warbler	2	18	20	+	.00
Blackpoll Warbler	1	10	11	+	.00
Wilson's Warbler	13	81	94	+	.00
Chipping Sparrow	187	63	250	-	.00
Savannah Sparrow	44	0	44	-	.01
Lincoln's Sparrow	332	29	361	o	.21
White-crowned Sparrow	10	3	13	o	.12
Dark-eyed Junco	430	41	471	o	.35
Bird species analyzed using All detections					
Gray Jay	7	6	13	+	.00
Red Crossbill	13	11	24	+	.00
Pine Grosbeak	4	3	7	+	.00
Pine Siskin	317	94	411	-	.00
Cavity nesting bird species All nest types					
Black-backed Woodpecker	26	20	46		
Hairy Woodpecker	0	4	4		
Three-toed Woodpecker	1	3	4		
Northern Flicker	6	2	7		
Pileated Woodpecker	0	1	1		
Total of All Woodpeckers	27	35	62	+	.00
Tree Swallow	44	1	45	o	.08
Red-breasted Nuthatch	3	24	27	+	.00
Mountain Bluebird	24	6	24	o	.10

[1] + indicates a significantly greater proportion in tree islands, - a significantly lower proportion, and o indicates no significant effect.

[2] Probability of the proportions of columns (1):(2) being significantly different from expected proportion of 90:10 based on approximate percentage of tree islands within entire experimental blocks (see text).

Red-breasted Nuthatch—One possible nest was found when a Red-breasted Nuthatch was excavating in an old snag 25 m from the forest edge in the TI Treatment unit of Block 5546 on 22 May.

Brown Creeper—Brown Creepers were probably breeding in the area since singing birds were regularly encountered but no Brown Creeper nests were found and no Brown Creepers were ever observed in any of the treatment units.

Mountain Bluebird—No Mountain Bluebird nests were found and it is not known if Mountain Bluebird were nesting in the treatment units even though they were regularly encountered there.

4.7 Chronology of Breeding Activities

Singing activity by all cavity nesters combined was highest on the first survey in mid May, and diminished steadily throughout the survey (Figure 7). All species which are suspected of breeding in the area, except the American Kestrel, were heard singing on the first survey (May 14-16). For Dark-eyed Juncos and Lincoln's Sparrows peaks in singing coincided with the fledging of the young (Figure 8). Possible explanations are an influx of finished nesters from elsewhere, a resurgence of singing by finished and/or failed nesters attempting to re-establish territories for second-nesting attempts, or weather related responses. Chipping sparrow singing activity remained relatively constant between late May and early July. Yellow-rumped Warbler singing peaked in late May, possibly the result of birds singing while on migration, and Townsend Warbler singing declined greatly after late June.

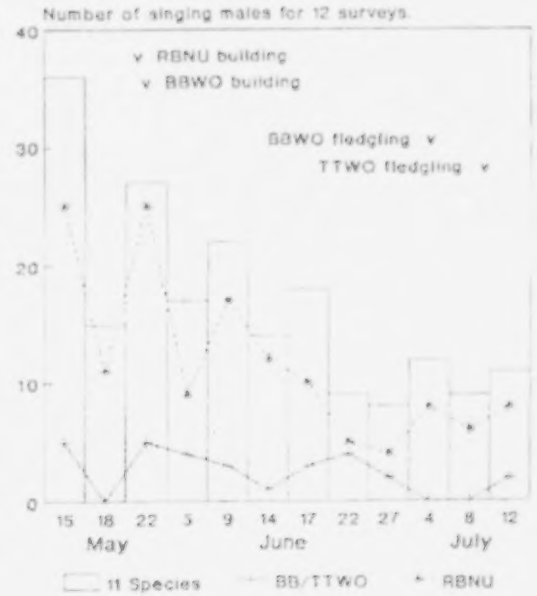

Figure 7. Chronology of singing cavity-nesting birds. (RBNU: Red-breasted Nuthatch; BBWO: Black-backed Woodpecker; TTWO: Three-toed Woodpecker)

Figure 8. Singing chronologies of 6 of the most common songbirds: Dark-eyed Junco, Lincoln's Sparrow, Chipping Sparrow, American Robin, Yellow-rumped Warbler and Townsend's Warbler.

5.0 DISCUSSION

Both stubs and tree islands were significant factors for some species of breeding birds within clearcut areas. The general effect was to raise "diversity" by providing additional habitat elements that could be used by more species within clearcuts. However, the effects that stubs and tree islands had on densities and diversity was not equal, with tree islands appearing to have much higher effects on a greater number of species.

5.1 Stub Effects

Creation of 3-m stubs had a positive and significant effect on habitat use for woodpeckers (mainly Black-backed) and for Tree Swallows. The same trend was suggested for American Kestrels based on numbers of detection on stubs, but sample sizes were too low for analysis. Some nests were also found in the stubs and significant numbers of cavity-nesters, as well as other birds, were using them as perches or feeding sites. Stubs will be used as intended by birds—for nesting, foraging perches, singing perches and foraging substrates. The net results of stub creation were fairly subtle compared to the much greater effect of tree islands. However, the value of stubs is probably critical for nesting Tree Swallows which made almost no use of the tree islands.

Detections of birds on stubs is not necessarily the most reliable estimate of stub use. For instance, Tree Swallows were observed less often than other cavity-nesting species on stubs, but exhibited the strongest stub effect on detection densities. Stubs were probably essential to Tree Swallows in these clearcuts, but their principal use was for nesting. Since Tree Swallows are aerial insect feeders, the stubs were not as important as foraging perches or substrates. The same may have held true for Mountain Bluebirds which had very inconsistent responses—they were never detected in the SI treatment. The conclusion might have been that they avoided stubs only when they were retained near tree islands, but this result is not immediately plausible and unknown nest locations may have significantly biased results. The level of detail needed to draw any conclusion about bluebirds is beyond the data that was collected in 1993. For American Kestrels and Olive-sided Flycatchers the stubs were probably important as foraging perches, and for Black-backed Woodpeckers, they were probably most important as foraging substrates. Clearly, no single measure based on first detections will identify the importance of stubs to all of these species.

There has been only one other study in British Columbia examining breeding bird responses to stubs (Bennett 1994). Looking at 4 densities of stub-retention (0, 3, 10 and 30 stubs/ha) in the Okanagan Highlands of the southern interior, a significant stub effect was shown for Mountain Bluebirds—stubs retained at any level increased Mountain Bluebird use of a clearcut. However, too few detections were made of Tree Swallows in that study, so that the analysis could not confirm the highly positive effect that stubs had on Tree Swallows in this study. No use was made of clearcuts, even with stubs, by Brown Creepers and no

appreciable use by Red-breasted Nuthatches. This confirms the results of this study where these two species showed little or no response to stubs at all. There did appear to be a threshold response to nesting in stubs in clearcuts with no nests found in stubs when densities were below 30 stubs/ha in the Okanagan study. Systematic nest searches were not made within the Donna Creek breeding bird study but should probably be part of future sampling.

The woodpeckers at the Okanagan study sites (Hairy and Three-toed Woodpeckers, and Northern Flickers) showed no consistent significant differences in habitat use with differing stub densities. The biggest difference between the Okanagan study and the Donna Creek study was in the size of the treatment units: Okanagan 4 ha; this study 25 ha. For wide-ranging birds such as woodpeckers, swallows or bluebirds, a 4-ha unit (i.e., 200 m x 200 m), even with only a few stubs, may be detected as a suitable patch for foraging, especially if the foraging behaviour is determined by a search image for stubs within clearcuts, and the adjacent units have stubs (albeit at different densities). The distances are relatively small in proportion to the size of the bird, and can be covered in a matter of seconds. Twenty-five-ha treatment units (i.e., 500 m x 500 m) may be slightly more daunting to venture into with no foraging opportunities obvious, especially when adjacent to another similarly-sized unit that is also without stubs. Without better data on micro-habitat use patterns within cavity-nesting bird territories, this will remain a matter of conjecture, as will the "ideal" size at which to conduct experiments on stub use.

In the first year of the Donna Creek Breeding Bird study, the stub effects were being monitored only in very recent clearcuts less than 2 years old. It cannot be reasonably assumed that the stubs would have received much use by species whose main habitat requirement is for closed canopy forest, such as Brown Creepers or Red-breasted Nuthatches. Use by these species may become more common as conifers regenerate on the site and the canopy closes. However, the openness of the clearcuts will persist for one or more decades so that use by forest species cannot be examined yet. This portion of the study must therefore concentrate its efforts on those species that can be expected to use these open clearcut areas. At Donna Creek, these are the American Kestrel, Mountain Bluebird, Tree Swallow, and, to some extent, the Black-backed Woodpecker and Olive-sided Flycatcher.

5.2 Tree Island Effects

Even though the small (1/4 ha) tree islands occupied only about 3% of the clearcut treatment areas, they had a pronounced effect on the bird communities present by doubling bird density and diversity. However, the effect was largely confined to the actual area of the tree islands for many species that rarely used the intervening clearcut habitat between the tree islands. For these species, the tree islands were habitat patches in a matrix of non-habitat. Notable exceptions were for Black-backed Woodpeckers, Yellow-rumped Warblers and Olive-sided Flycatchers. For these three species, the presence of tree islands significantly

increased stub use in the clearcut portions of the treatment unit. It might also be stated (using the same data) that the presence of stubs increased the use of tree islands, but the finely detailed density data within tree islands needed to examine that relationship is not yet available.

Some forest bird species were never, or extremely rarely, found in the tree islands. For these species, 1/4 ha tree islands will simply not be large enough to provide habitat within a clearcut. These species include Brown Creeper, White-winged Crossbill, Hammond's Flycatcher, Winter Wren, Varied Thrush and Tennessee Warbler. Using one species as an example, Brown Creepers had breeding territory sizes of 2.3-6.4 ha in Michigan (Davis 1978) and the very similar Treecreeper *(Certhia familiaris)* was absent from forest patches of less than 10 ha in Sweden (Loman and von Schantz 1991). Clearly, on the short-term within clearcuts, small tree islands will not serve these species.

The size of tree islands within the treatments also had an effect on two breeding bird species in particular. The only Red-breasted Nuthatch breeding territory within the tree islands in the treatments was probably in the single 1-ha tree island. Similarly, the Townsend's Warbler data was re-examined because no significant tree island effect was found even though 18 of the 20 Townsend's Warbler detections in the treatments were from within tree islands and the habitat use of the species in the treatments was clearly influenced by tree islands. The mean densities had relatively high dispersion because 12 of the 20 locations all came from the same 1-ha tree island. This larger tree island was probably the only location that Townsend's Warblers held a breeding territory in the clearcuts. The potential for this one larger tree island to cause bias in the data is significant and must be allowed for in future analysis by considering tree island area as one of the independent variables.

Small tree islands of about 1/3 ha are the smallest tree island that should be considered as wildlife tree patches, and there is every reason, as found for Red-breasted Nuthatches and Townsend's Warblers, to believe that tree islands should be larger. Within tree islands any smaller than 1/3 ha, there will simply be no opportunity for retaining any tall snags (> 20-m height) and it is precisely these tall and large diameter snags that are of the most use to cavity-nesting species (Backhouse 1993). Any snag in such a small tree island will almost always be within 1-and-a-half tree lengths of the edge of the clearcut (i.e., working area) and must be felled according to Worker's Compensation Board regulations (Backhouse 1993). Designating a no-work zone around the tree island is impossible, since, by definition, anything that is clearcut is part of the working area. Blowdown of trees within these small tree islands was also a problem (Mari Wood, pers. comm.).

It was not known just how many of the singing birds detected within the tree islands were actually breeding there. Many of the breeding birds in these patches (particularly those that did not use adjacent clearcut habitat to an appreciable extent), may have been using several patches as one territory, or part of the nearby forest as part of a territory, or they

may not have been successfully-breeding males. It has been recently been shown that unpaired male songbirds sing much more often than paired males, and are almost always detected on song surveys while the paired males are much quieter and frequently missed (Gibbs and Wermy 1993). The effect of this possible bias may be very high if song counts are used as the measure of habitat use (and therefore quality) of the tree islands for breeding songbirds. These biases cannot be countered by using more intensive spot-mapping techniques. Spot mapping requires interpretation of clusters of singing detections. If the clusters are in reality "broken-up" into sub-clusters by tree islands, the results become impossible to interpret. Only by using nest searches to determine true density, and using either colour-banding or radio-telemetry studies to determine real habitat use, can the real habitat quality of these tree islands be determined.

The extent to which the tree islands would have been used if adjacent Old-Growth was unavailable is unknown. Some species may have used the tree islands, but the use may have been peripheral to ranges in the adjacent Old-Growth forests. Through the next timber-harvest passes, the adjacent Old-Growth will no longer necessarily be available, and the forest within the clearcut may not have regenerated to the point where it again has become suitable breeding habitat. In the southern interior of B.C. Three-toed, Hairy and Pileated Woodpeckers used 2-ha tree islands as habitat patches without making significant use of the surrounding clearcut even 25 years after clearcutting (Gyug 1994). Obviously, timber-harvesting techniques need to be developed that allow for these species to establish stable populations that are not dependent on adjacent old-growth habitat to sustain them. Small (1/4 ha) tree islands may not accomplish this. Studies that are much more far-reaching and comprehensive are still needed to confirm the value of adjacent forests beyond the site level. Some of these questions may be addressed by the Donna Creek study if continued over the long-term, but is beyond its present short-term scope.

5.3 Bird Communities

The effect of both stubs and tree islands was to increase the number of species per bird detected (Figure 6) but there are several possible interpretations of what this baseline means. The log-log regression of the most uniform habitats in the study area (the CC Treatment and the Old-Growth Controls) has provided some sort of baseline about which we can examine other habitats for species richness. Species richness was higher in the TI and SI treatments because of the presence of tree islands. However, this result was not exactly unexpected since any creation of patchiness in an otherwise uniform habitat should increase species richness (Wiens 1989b:128).

The base regression line on Figure 6 may have little validity. Of more interest would be wider comparisons of the successional trends from a clearcut to a managed forest, as well as from a natural disturbance to an Old-Growth forest (since managed forests may have less habitat heterogeneity and be more uniform than Old-Growth forests). Only by examining

this wider array of sites with different treatments and at different successional stages could this be explored in more detail. This is beyond the present scope of this project but is still of interest in comparing timber-harvest treatments to natural-disturbance regimes at the community level. However, of particular interest is where the bird community of a fire-disturbed area would fit on this regression in comparison to the treatments under study. In particular, study of a recently burned (and unsalvaged) site would be the natural-disturbance equivalent to stub creation. This might indicate the "maximum" potential for stubbing in clearcuts. The standing dead trees should maximize nesting, tree-trunk foraging and perching possibilities. If bird use of the burned sites were very different from the stubbed clearcuts, then other levels of stubs beyond 8-10/ha become very relevant factors that could be investigated in other studies. The addition of such sites (if available) would not add considerably to the cost of the project but would greatly increase its applicability.

6.0 ASSESSMENT OF SAMPLING

The strongest features of this study were the 2x2 ANOVA study design that allowed determination of stub, tree island and interaction effects, as well as the large size of the treatment units compared to the small breeding territories of most songbirds. However, the principal limiting factors of this study to date were: (1)the fairly large territory size of some of the cavity-nesting focus species relative to the treatment units, (2)the inadequacy of the sampling design, and (3)the low number of replicates of the treatment units. The size of the treatment units cannot be now changed so that territory sizes of species can only be addressed through different methods or simply by consideration of territory sizes when drawing conclusions (i.e., were whole territories or fragments of territories being sampled in the treatment units). The number of replicates is also fixed and cannot be easily changed although its effects must be considered. Within these constraints, the sampling design must be the most efficient possible to give the experiment the greatest power to determine stub and tree island effects on breeding birds. These aspects are discussed below.

6.1 Statistical Power

Estimation of effect sizes and statistical power reported in the 2x2 ANOVA tables, allowed us to determine the strength of this experimental design. Cohen (1988) has defined a large effect size (f) as a value of 0.4. Effect size (f) is a dimensionless measurement not dependent on the mean or variance but constant for a given statistical test (e.g. for ANOVA). In this study, significant responses (i.e. when alpha ≤ 0.05) were consistently achieved only for effect sizes of 0.7 or larger. These were termed here "very large" effect sizes. The power of the 2x2 ANOVA with 3 replicates to detect large effect sizes was only a very poor 20%. In other words, there was only a 20% chance of detecting a large effect as significant even when it was present. To put these effect sizes in more practical terms for breeding

birds, effect sizes of 1.0 or greater approach presence/absence levels that should be obvious fairly quickly to trained observers (e.g. absence of Tree Swallows from treatments without stubs, Table 6, or absence of Swainson's Thrushes outside of tree islands, Table 5). Effect sizes of 0.4 may be slightly more subtle because species are more uncommon or show higher variability (e.g. Pine Grosbeak use of tree islands, Table 6, or positive effect of stubs on increasing species richness, Table 5). Determining the significance of these large effect sizes would usually require statistically valid sampling and subsequent analysis to counter typical observer subjectivity.

To obtain what has been termed a reasonable statistical power of 80% (Cohen 1988) for large stub and tree island effect sizes would have required 12 cutblocks, each containing the 4 treatments. Obtaining 9 more cutblocks for this study is not immediately feasible but there is an alternative statistical method to raise power to detect large true effect sizes: alpha (the probability of a Type I error) can be raised until it equals beta (the probability of a Type II error). In this experimental design with 3 replicates, alpha equals beta at 0.36 for large effect sizes, and then power will equal 64%, which is the maximum that can be achieved for large effect sizes and only 3 replicates using this method. In terms of interpretation of this study, alpha might therefore be raised to 0.36 as the level below which effects are accepted as significant. Using this criterion, the 2x2 ANOVA tables could be re-interpreted.

Revisiting the 2x2 ANOVA tables (Tables 5-7) with this criterion, stubs were seen to have significant effects on the species richness of singing birds, and total densities of singing birds and all birds. Tree islands were seen to have a significant positive effect on Gray Jays, Pine Grosbeaks, Pine Siskins, Ruby-crowned Kinglets, American Robins, Townsend's Warblers, Wilson's Warblers, Western Wood-pewees, Chipping Sparrows, Lincoln's Sparrows and White-crowned Sparrows, and a significant negative effect on Savannah Sparrows. Significant stub and tree island interactions effects were added for species richness of singing birds, American Robins and Red Crossbills. A few of these effects are hard to interpret, e.g. the positive effects of tree islands on Lincoln's Sparrows, but for most other species the results were biologically plausible and generally support the tree island effects found for species in Table 11. In addition, the block effect is significant for Red-breasted Nuthatches and Tree Swallows so that this would still have to be accounted for in future analyses.

Power of the study design will not be greatly increased by increasing the number of years of sampling. Using a Repeated Measures Design, the statistical power to detect differences between treatments does not increase. Only the power to detect between year differences increases as more years of data are gathered. Multi-year sampling might increase precision of the treatment means (as does repeated sampling within a single breeding season) and thereby increase the power of the experiment. Annual fluctuations may act to decrease this precision, rather than increase it, but this cannot be evaluated without actual data from the sites. Results from two consecutive years on the sites should indicate the extent of some of the species annual fluctuations, so that the best long-term sampling design can be applied.

Statistical power for Old-Growth Control comparisons to treatments using Dunnett's procedure can be raised very simply by sampling more Old-Growth Control replicates. Montgomery (1991:80) has suggested the ratio of control replicates to treatment replicates should equal the square root of the number of total treatments (including control). In this study that implies 7 control replicates as the optimal number. However, study of the results in Tables 8 and 9, show that Dunnett's Procedure had fairly good resolving power for species that were uncommon in the controls but very uncommon in the treatments (e.g. Tennessee Warbler and Spruce Grouse). Dunnett's procedure seemed to have fairly low resolving power for species that were common in all 4 treatments but very uncommon or absent in the Old-Growth forest (e.g. Savannah Sparrows, Lincoln's Sparrows and White-crowned Sparrows). At this stage of this study, effort may be better spent examining stub and tree island use within clearcuts than sampling more Old-Growth Control replicates.

Raising the number of replicate experimental cutblocks to 12 for this study, would still amount to a tiny fraction of the number of cutblocks actually harvested in B.C. in any one year. Three replicates is an even smaller fraction of the cutting presently taking place annually in B.C. so that any large effect seen in this study, multiplied hundreds of times over, may have great biological significance on a given species. Consequently, each species response should be examined especially carefully when the effects under study here were found to be very large and significant at the very conservative alpha equals 0.05 level.

6.2 Timing of Sampling

For the most consistent results, timing of sampling for breeding songbirds should be when pairs are on their breeding territories and males are singing and detectable. In the Donna Creek area, the best timing for sampling most songbirds will be the period including the last week of May and the first 3 weeks of June. Sampling for Red-breasted Nuthatches can begin earlier in May through mid-June and sampling for woodpecker drumming is probably best even before mid-May during nest building. Sampling for Mountain Bluebirds, American Kestrels and Tree Swallows can be at the same time as for other songbirds.

Singing detections of birds may not be an adequate measure for all cavity-nesting species because some of the cavity-nesting species simply do not advertise on territories in the same sense as typical songbirds. This includes Mountain Bluebirds, American Kestrels and Tree Swallows which, along with Black-backed Woodpeckers, were the most abundant cavity-nesting birds in the clearcut areas of the study treatments.

For resident cavity-nesting birds, sampling need not be limited to the breeding period. As for many resident animals, winter is often the critical period of resource shortages. The problem with sampling wintering birds is that in some years there may be extremely few birds to sample in an given area if they have moved to a geographical area of higher winter

resources. This will not be considered further here, but is part of any overall species strategy that needs to be considered for resident cavity-nesters.

6.3 Sampling Techniques

It has already been shown in this report that the habitat use of some bird species was different at different levels of stubs and tree islands, i.e there were significant stub and tree island effects for some species. Habitat use in this case was measured as numbers of detections per unit time and area and has been termed density throughout this report. To this end, any rigorous sampling methodology which garners unbiased detections will be appropriate. Transects were used here, but point counts would also have worked. In fact, point counts would have functioned much better because the points could have been placed where they did not cross treatment unit boundaries thereby reducing confusion for observers about which treatment unit to assign detections to within single transects. This could also have been avoided by simply having transects wholly within single treatment units so that they did not cross treatment unit boundaries, but only very short transects would have fit all treatments because of different sizes and shapes of units.

Transect sampling was also not the most suitable method for sampling what turned out to be a very non-homogeneous habitat, i.e., the treatment units with tree islands. One of the 22 tree islands even fell completely outside all the sampling transects, and 6 more were only partly sampled, or sampled partly in one transect and partly in another. Much more suitable would have been point counts where points can be placed for stratified random sampling with unequal sampling fractions. In this case, one strata would have been the "clearcut" areas outside of tree islands, and the other would have been the tree islands themselves. Since the tree island comprise such a small percentage of the total habitat, all detections in tree islands could be significant. The point count method would provide 100% coverage of the tree islands for comparisons to other habitats which will be sampled at less than 100% coverage. Overall detection densities in a treatment unit then become the weighted sum (by area) of the means of the two strata.

Traditional breeding songbird sampling techniques work best for species with relatively small breeding territories that completely fit into small plots. For these birds, sampling of small plots is relatively efficient because the birds with breeding territories will be present (although not necessarily active) on every survey visit. Except for Red-breasted Nuthatches and Brown Creepers, cavity-nesting birds simply do not fit well into this group with only very inexact measures of habitat use possible using these techniques. Some of this bias may be reduced by expanding sampling plot boundaries using wider radius techniques such as playback responses, but the limitation of this technique will still be the size of the treatment units themselves. For wide-ranging birds, it is also not known whether birds are outside the plot or are simply inactive on the plot. This may be especially confounding for birds that regularly fly across the treatment unit boundaries in this study. The extent to

which use of adjacent treatment units influences habitat use in the treatment unit being campled can only be measured by following individual birds for given time periods, either visually as in typical behavioral studies, or by radio-tracking, which will provide an even better unbiased estimate of habitat use. The advantage of using standard behavioural techniques of visually following birds is that stub and tree island use can also be assessed at the same time.

7.0 RECOMMENDATIONS

7.1 Alternative Methods to Determine Factor Effects on Target Species

1. The number of active cavity-nests in the treatments is essential to interpretation of the detection density data. There will likely be very few active cavity-nests in the experimental blocks so that complete searches of the treatment units can be fairly easily made. The most fruitful method is likely to involve following detected birds (e.g. Martin and Geupel 1993) although that may be combined with some sort of systematic search of the stubs.

2. Mountain Bluebird, American Kestrel and Tree Swallow are simply not adequately sampled through "songbird" methods. The numbers of detections of each species can be increased by using techniques typical of behavioural studies. These studies have many potential sources of bias, but these can be reduced through proper planning. Results will not be comparable between forest and clearcut habitats because of greatly different detectability of birds (Bradley 1985) so that these methods should be confined to the experimental blocks where they will be most fruitful. A rigid and unbiased scheme must be developed that spreads detection likelihood evenly over each treatment. A detected bird is followed for a given period of time (termed a time-series) and behaviours, as well as approximate location relative to treatment units and tree islands, recorded at fixed intervals (perhaps every 10 or 20 seconds). The objective is to construct behavioural budgets for species with respect to location within treatment units (especially if the selected bird crosses treatment unit boundaries while being observed), and to stubs and tree islands. Typically, 30 time-series must be gathered for time budgets to stabilize for a species (Morrison 1984). There may be some built-in biases to this method if the same individuals might be used repeatedly for what are thought to be independent time series (Machlis et al. 1985), but this is not easily resolved without banding birds for individual identification.

3. For the cavity-nesting species with individuals that often crossed treatment unit boundaries, there may be "nearest-neighbour" effects on the CC Treatments because stubs were available for nesting in the adjacent treatment units (e.g. for American Kestrels or Mountain Bluebirds). Only by selecting similar size treatment units within conventional clearcuts can this effect be discounted. This would determine if there was a spillover of stub

or tree island effects into the CC Treatment, or if the CC Treatments were truly representative of conventional clearcuts.

4. For "Forest" cavity nesters, e.g. Red-breasted Nuthatches or woodpeckers, detectional techniques as above will be significantly biased by observability in different habitats (i.e. tree islands vs clearcuts). Within habitat comparisons should still be valid and any cavity-nesters detected during #2 above should be observed. Olive-sided Flycatchers should also be observed since they showed significant stub effects.

5. Uniquely marking birds to distinguish actual breeding pair territories would also reduce bias in observational studoes. Radio tagging would also be the only effective way to determine unbiased measures of habitat use comparing open clearcut and closed forest habitats. Examples include Bull and Holthausen (1993) for Pileated Woodpeckers, and Bull and Beckwith (1993) for Vaux's Swifts. The results of the simpler observational techniques in the open habitats outlined above should be evaluated after the 1995 field season to either refine the techniques for target species, or to suggest different methods.

7.2 Conventional Methods for All Breeding Birds

1. The research need and the study design were the strongest parts of this breeding bird survey to date. Sampling methodologies were not acceptable because of the misapplication of transects to a distinctly non-uniform habitat (tree islands). Spot-mapping is not possible for these small tree islands either as previously outlined. Only point counts are an acceptable methodology.

2. Recommended methods are 50-m radius 10-minute point counts. The Old-Growth Controls and the CC, SB, and "Clearcut" strata of the TI and SI Treatments should be sampled evenly. Seven points placed in each treatment unit should be sampled 8 times each from mid-May to late June between 1/2 hour before sunrise and 10 A.M. 23 additional points will need to be placed in the tree islands (21 tree islands x 1 point + 1 larger tree island x 2 points because of its shape) and the area of each tree island measured precisely. At all points, first detections are recorded. Territorial behaviours such as singing should be recorded since densities of territorial males is of interest. If the territorial behaviour is not the first detected behaviour, that should be noted. The detection protocol should be that of Hutto et al. (1986) except that birds known to enter the 50-m radius during the count period recorded as inside but with an annotation noting the fact so that the potential for bias can be estimated. Birds flushed and leaving the radius as the observer enters the circle are counted as being in the radius. While doing the point counts, the approximate position and behaviour of all cavity-nesters should be recorded, at any radius. This data will not form part of the point count analysis because of inherent biases, but will assist in interpretation of the 50-m radius data that is collected.

3. Point sampling for woodpeckers should begin in April and continue into May. Playback techniques at selected points should increase cavity-nester responses to collect enough detections to permit analysis but the points must be placed far enough apart to be independent samples. The habitat that the cavity-nester responded from must also be recorded in case the response is across treatment unit boundaries.

4. Breeding bird sampling should be in 2 consecutive years at this stage of this project. This will permit evaluation of annual fluctuations in some of the species with as little "noise" as possible from vegetation changes on the sites so that the best long-term sampling design can be established.

5. Three additional "Natural Disturbance" controls should be selected. These would be unsalvaged burns of a similar age and size to the experimental cutblocks to demonstrate the "maximum" potential of stubbing in clearcuts. If there are such sites in the area, then they should be sampled, at the bare minimum, at a reconnaissance-level (single visit using same point count methodologies as above).

6. Four new Old-Growth Control replicates should be selected adjacent to the present cutblocks if funding permits but is lower priority at this stage than the Alternative Methods previously outlined.

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APPENDICES

Appendix 1. The compiled number of singing bird detections by species for each treatment unit. The 3 figures are for Cutblocks 5516, 5546 and 5547 respectively. Where all 3 were zero, a single "O" has been substituted. For treatment units with tree islands, detections within tree islands are presented separately.

				"clearcut" areas only		"tree island" patches only	
	Old-Growth	Clearcut	Stubs	Tree Islands	Stubs-and-Islands	Tree Islands	Stubs-and Islands
American Kestrel	0	0	0	0	0,1,0	0	0
Solitary Sandpiper	0	0	0,1,1	0,1,0	0,0,1	0	0
Spotted Sandpiper	0	0	0,1,1	0	0,0,1	0	0
Three-toed Woodpecker	3,1,0	0	0	0	0	0	0
Black-backed Woodpecker	2,1,1	0	1,0,0	0	1,0,0	0	0,3,0
Northern Flicker	0	0	0	0	0	0	1,0,0
Pileated Woodpecker	0	0	0	0	0	0	1,0,0
Unidentified Woodpecker	4,1,0	0	0	0	0	1,0,1	0
Olive-sided Flycatcher	2,2,1	1,0,0	0	2,1,0	1,0,0	1,0,1	3,2,4
Western Wood-Pewee	4,0,1	0	0	0,0,1	0	0,1,1	0,0,7
Hammond's Flycatcher	1,2,15	0	0	0	0	0,0,10	
Pacific-slope Flycatcher	0,0,2	0	0,1,0	0,0,1	0	0	0,0,1
Tree Swallow	0	0	1,2,0	0	2,0,0	0	0
Gray Jay	0,1,0	1,0,0	0	0	1,0,0	1,0,0	0
Mountain Chickadee	0	0	0	0	1,0,0	1,0,0	0
Boreal Chickadee	1,0,0	0	0	0	0	0	0
Red-breasted Nuthatch	26,41,31	0	0	0,1,0	1,0,0	11,0,2	7,2,2
Brown Creeper	1,6,4	0	0	0	0	0	0
Winter Wren	18,9,19	0	0	0,0,1	0	0	0,0,2
Golden-crowned Kinglet	53,53,43	0	0	0,1,0	0	1,0,1	0,1,2
Ruby-crowned Kinglet	12,18,19	0	0	0	0	8,0,1	3,0,0
Mountain Bluebird	0	0	0,1,0	0	0	0	0
Townsend's Solitaire	0	0,1,0	0	0	0	0	0
Gray-cheeked Thrush	0	0	0	0,0,1	0	0	0
Swainson's Thrush	68,80,49	0	0	0	1,0,0	9,1,8	8,1,9
Hermit Thrush	0,0,1	0	0	0	0	0	0
American Robin	21,4,16	6,7,3	3,3,5	7,0,6	6,0,2	2,1,6	6,2,9
Varied Thrush	19,11,27	0	1,0,0	0	0	0	1,0,0
Solitary Vireo	0,1,0	0	0	0	0	0	0,1,0
Warbling Vireo	0,1,0	0	0	0	0	1,0,0	0
Tennessee Warbler	1,4,6	0	0	0,1,0	0	0	0
Orange-crowned Warbler	0,1,0	0	0	0	0	1,1,0	0
Yellow-rumped Warbler	72,89,87	6,10,1	2,2,2	8,1,4	2,2,3	21,11,18	19,15,17
Townsend's Warbler	185,203,177	0	0	0,0,1	1,0,0	12,0,1	2,2,1
Blackpoll Warbler	38,33,61	0	0	1,0,0	0	2,0,5	1,0,2
Ovenbird	0,1,0	0	0	0	0	0	0
Northern Waterthrush	0,0,5	0	0,0,1	1,0,0	0	0	0,1,0
MacGillivray's Warbler	4,0,0	0	1,0,0	0	0,0,1	0,0,1	0,1,0
Wilson's Warbler	35,54,44	0	0,1,0	5,3,3	1,0,0	14,9,15	11,12,20
Western Tanager	0,1,1	0	0	0	0	0	0
Chipping Sparrow	41,35,31	27,18,5	12,8,29	29,12,16	10,9,12	21,4,13	3,7,15
Clay-colored Sparrow	0	0	0	0	0,0,1	0	0
Savannah Sparrow	0	0,21,4	0,6,5	0,1,4	0,0,3	0	0
Lincoln's Sparrow	1,0,0	39,7,13	21,28,57	21,32,40	18,32,24	1,9,8	0,2,9
White-throated Sparrow	0	0	0	0,0,1	0	0	0
White-crowned Sparrow	0	0	0,0,1	1,1,4	1,0,2	0	0,0,3
Dark-eyed Junco	3,12,12	34,28,26	45,37,66	57,33,19	48,21,16	6,5,7	11,8,4
Pine Grosbeak	3,1,0	0	0	0	0	0	1,0,0
Red Crossbill	1,2,0	0	1,0,0	0	0	0	0,0,1
White-winged Crossbill	8,1,3	0	1,1,0	0	1,0,0	0	0
Pine Siskin	17,11,7	4,1,0	1,0,3	1,0,2	0,0,2	5,1,9	1,0,7
Evening Grosbeak	1,1,2	0	0	0	0	0	0
Unidentified Bird	3,0,1	0	0	0	0,1,0	2,0,0	0

Appendix 2. The compiled number of all bird detections by species for each treatment unit. The 3 figures are for Cutblocks 5516, 5546 and 5547 respectively. Where all 3 were zero, a single "O" has been substituted. For treatment units with tree islands, detections within tree islands are presented separately. Sampled area of each treatment unit is provided except for tree island areas, which were not measured precisely.

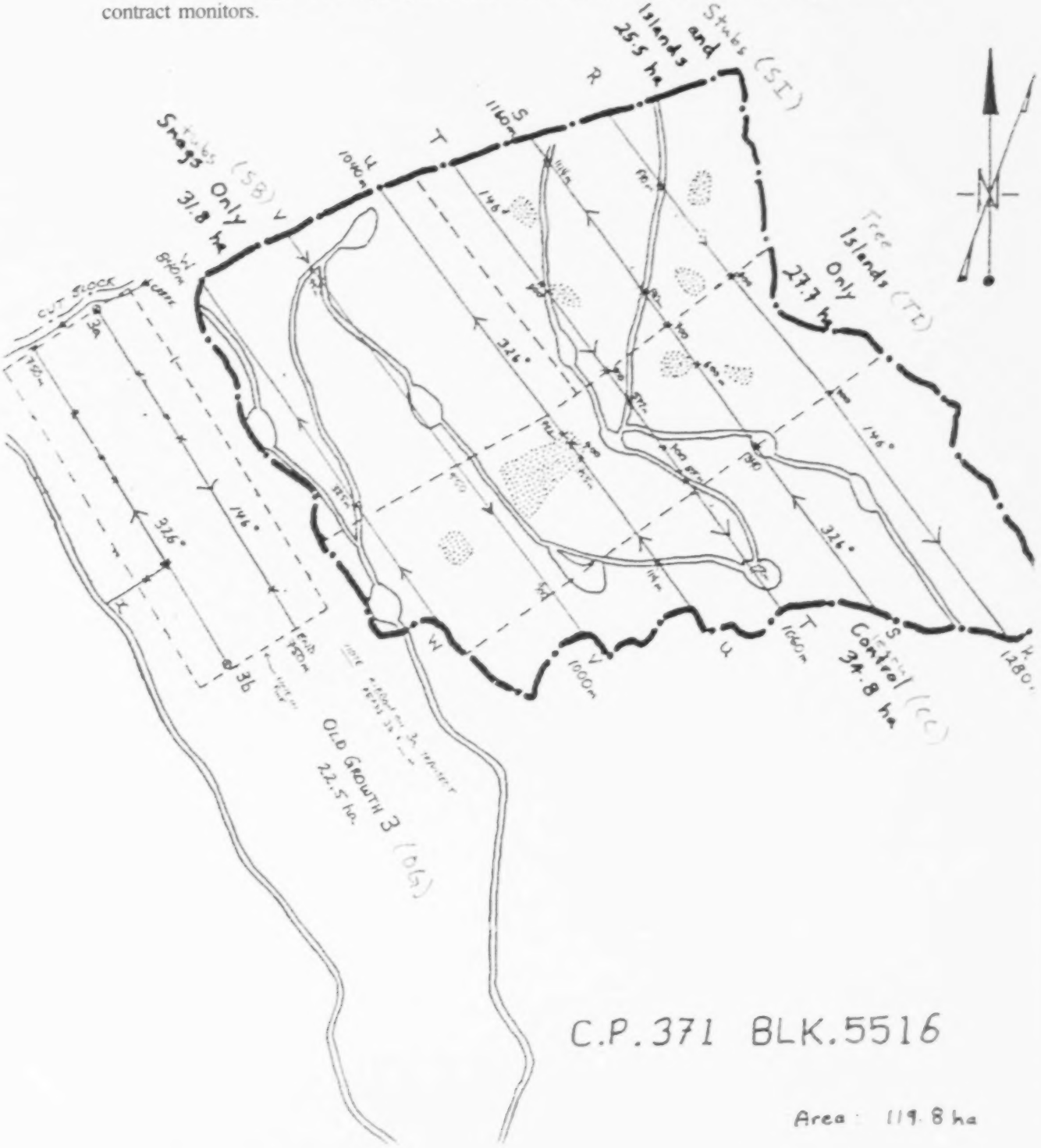
				"clearcut" areas only		"tree island" patches only	
	Old-Growth	Clearcut	Stubs	Tree Islands	Stubs-and-Islands	Tree Islands	Stubs-and Islands
Area Sampled:							
5516	22.50	21.87	23.48	27.25	20.25		
5546	20.63	18.25	16.05	19.50	15.32		
5547	22.88	17.78	34.93	26.10	16.23		
Mallard	0	0	0	0	0,0,3	0	0
Sharp-shinned Hawk	0	0	0	0	0	0,0,1	0
Golden Eagle	0	1,0,0	0	0	0	0	0
American Kestrel	0,0,1	0,1,0	0,1,0	0,1,0	0,2,1	0,1,0	0
Spruce Grouse	2,4,3	0	1,0,0	0	0	1,0,0	0
Sora	0	0	0,1,0	0	0	0	0
Solitary Sandpiper	0	0	4,2,0	0,1,0	0,0,1	0	0
Spotted Sandpiper	0	0	0,5,1	0	0,0,1	0	0
Rufous Hummingbird	0	0	0	1,0,0	0	0	0
Three-toed Woodpecker	13,9,2	0	0	0	0,0,1	0	0,0,3
Black-backed Woodpecker	12,2,3	2,0,2	6,1,0	3,0,0	9,3,0	5,1,0	2,11,1
Northern Flicker	0	0	0	0	0	0	1,0,1
Pileated Woodpecker	0	0	0	0	0	0	1,0,0
Unidentified Woodpecker	12,9,0	0	0	0	0	4,0,2	1,1,1
Olive-sided Flycatcher	2,2,1	1,0,0	0	2,1,0	2,0,0	1,0,1	3,2,4
Western Wood-Pewee	4,0,1	0	0	0,0,1	0	0,1,1	0,0,7
Yellow-bellied Flycatcher	0	0	0	0	0,0,1	0	0
Hammond's Flycatcher	1,2,15	0	0	0	0	0,0,1	0
Pacific-slope Flycatcher	0,0,3	0	0,3,0	0,0,1	0	0	0,0,1
Tree Swallow	0	1,1,0	8,9,3	0,1,0	11,7,3	0	0,0,1
Gray Jay	11,10,11	1,0,0	0,0,1	1,0,2	2,0,0	2,0,0	1,3,0
Steller's Jay	0	0	0	0	1,0,0	0	0
Common Raven	0	0	0	0,1,3	0	0	0
Mountain Chickadee	0	0	0	0	1,0,0	1,0,0	0
Boreal Chickadee	1,1,1	0	0	0	0	0	0
Red-breasted Nuthatch	27,42,33	0	0	0,2,0	1,0,0	11,0,2	7,2,2
Winter Wren	24,12,21	0	0	0,0,1	1,0,0	0	0,0,2
Brown Creeper	4,7,9	0	0	0	0	0	0
Golden-crowned Kinglet	93,97,85	0	0	0,1,0	0	1,0,2	0,1,2
Ruby-crowned Kinglet	13,21,19	0	0	0	0	10,0,1	4,0,0
Mountain Bluebird	0	0,4,1	4,3,6	3,2,1	0	0	0
Townsend's Solitaire	0	0,1,0	0	0,0,1	0,0,1	0	0
Gray-cheeked Thrush	0	0	0	0,0,1	0	0	0
Swainson's Thrush	97,100,76	0	1,0,0	3,0,0	1,0,0	11,1,10	9,1,12
Hermit Thrush	0,0,2	0	0	0	0	0	0
American Robin	46,7,22	12,16,6	15,21,19	12,6,17	16,15,12	5,4,8	8,3,12
Varied Thrush	21,11,28	0	1,0,0	0	0	0	1,0,0

(continued on next page)

Appendix 2. (continued)

				"clearcut" areas only		"tree island" patches only	
	Old-Growth	Clearcut	Stubs	Tree Islands	Stubs-and-Islands	Tree Islands	Stubs-and Islands
American Pipit	0	0	0,1,6	0	1,0,1	0	0
Cedar Waxwing	0	0	0	0	0,0,1	0	0
Solitary Vireo	0,1,0	0	0	0	0	2,0,0	0,1,0
Warbling Vireo	0,1,0	0	0	0	0	1,0,0	0
Tennessee Warbler	1,4,6	0	0	0,1,0	0	0	0
Orange-crowned Warbler	0,2,0	0	0,1,0	0,0,1	0	1,1,0	0
Yellow-rumped Warbler	77,98,95	8,25,6	9,7,13	18,4,7	11,10,12	26,23,22	19,21,24
Townsend's Warbler	201,212,187	0	0	0,0,1	1,0,0	13,0,1	2,2,1
Blackpoll Warbler	38,33,64	1,0,0	0	1,0,0	1,0,0	2,0,5	1,1,2
Ovenbird	0,1,0	0	0	0	0	0	0
Northern Waterthrush	0,0,5	0	0,0,1	1,0,0	0	0	0,1,0
MacGillivray's Warbler	4,0,0	0	1,0,0	1,0,0	0,0,1	0,0,1	0,1,0
Wilson's Warbler	48,59,54	1,1,0	0,1,2	5,5,3	4,1,1	18,13,21	11,13,21
Western Tanager	0,1,1	0	0	0	0	0	0
Chipping Sparrow	51,41,50	41,28,14	34,10,48	35,21,26	19,15,19	24,14,18	7,14,21
Clay-colored Sparrow	0	0	0	0	0,0,1	0	0
Savannah Sparrow	0	1,38,4	0,8,9	2,1,8	0,0,4	0	0
Lincoln's Sparrow	1,0,0	48,31,51	40,41,93	38,57,83	28,55,49	3,12,14	0,7,14
White-throated Sparrow	0	0	0	0,0,1	0	0	0
White-crowned Sparrow	0	1,0,0	0,0,3	1,1,4	1,0,3	0	0,0,3
Dark-eyed Junco	17,28,30	93,89,71	164,100,163	150,88,125	138,91,90	18,21,31	24,18,16
Rusty Blackbird	0	0	0,3,0	0	0	0	0
Pine Grosbeak	4,1,0	2,0,0	0	2,0,0	0	0,0,1	4,2,0
Red Crossbill	4,8,0	12,0,0	1,0,0	0	0	5,0,0	1,0,5
White-winged Crossbill	13,7,8	0	1,1,0	0	1,0,0	1,0,0	0
Pine Siskin	74,43,54	35,7,2	60,10,7	149,1,23	0,1,22	25,5,23	15,6,20
Evening Grosbeak	11,3,8	0	0	0	0,1,2	0,0,2	0
Unidentified Bird	8,7,13	3,3,6	7,1,3	1,5,6	3,3,2	4,1,2	0,0,1

Appendix 3. Experimental Block maps at 1:10,000 showing treatment unit boundaries, Old-Growth Control areas and sampling transects used in 1993. Reproduced here as provided by contract monitors.



Appendix 3. (Continued)

Appendix 3. (Continued)